Ultra-Deepwater & Unconventional Gas 2007-2008 Research & Development Plan

DOE/NETL-2007/1283

EPACT Section 999 Initial Annual Plan for the Ultra-Deepwater and Unconventional Onshore Natural Gas and Other Petroleum Research and Development Program

May 2007

Disclaimer

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May 2007

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Executive Summary

Subtitle J, Section 999, of the Energy Policy Act (EPAct) of 2005, calls for the establishment of an Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Resources Research and Development Program. The legislation identifies three program elements to be administered by a consoritium under contract to the Department of Energy including ultra-deepwater architecture and technology, unconventional natural gas and other petroleum resource E&P, and technology challenges of small producers. Complementary research performed by the National Energy Technology Laboratory (NETL) is a fourth program element. NETL is also tasked with managing the consortium.

As directed by the legislation, NETL solicited proposals for the consortium and awarded a contract to The Research Partnership to Secure Energy for America (RPSEA) in late 2006. NETL worked closely with RPSEA to develop this initial comprehensive Draft Annual Plan that frames the work to be accomplished during the first two years of the program. A large number of inputs from industry workshops, roadmapping sessions and expert opinions, were used to formulate this first Annual Plan. Figure 1 illustrates the areas of emphasis identified in this initial plan. These areas were identified as the most important for the $50 million/year for the first two years.

The Ultra-deepwater Program Element is divided into theme areas based on four generic field types that represent the most challenging field development scenarios facing deepwater operators. The Consortium will solicit R&D projects that seek to develop technologies that will enable development of these types of fields. Along with these four areas is a group of eight crosscutting challenges that represent the areas where new technologies are needed to advance the pace of ultra-deepwater development for all field types. The Consortium will also solicit projects that seek to advance technologies in each of these areas as components of an integrated system.

The Unconventional Gas and Other Resources Program Element is divided into three theme areas that target gas shales, water management for both coalbed methane and gas shales, and tight sands. Here the Consortium is focusing on unconventional gas rather than “other resources” (e.g., shale oil, oil sands, deep gas) where R&D to help translate resources into reserves is also needed. The complementary R&D to be carried out by NETL will target some of these resources.

The Small Producers Program Element theme area targets advancing technologies for mature fields which primarily covers the technology challenges of managing water production, improving recovery and reducing costs. Mature fields are the domain of the small producer and these three challenges are at the top of every small producer’s list of problems to be dealt with on a daily basis.

For each of the Consortium administered program elements, a number of “sub-themes” have been developed to help guide the solicitation process. These sub-themes are

detailed in Tables 1 and 2. The process of prioritization that has led to these lists is provided in greater detail in Sections 2.1, 2.2 and 2.3 of the Plan. The Solicitation process that will be followed to generate a portfolio of R&D projects to address these themes is described in Section 2.4.

The Complementary R&D Program Element will have four principal areas of focus, described in the Plan as Centers operating within the NETL Office of Research and Development. These four focus areas are:

- Drilling Under Extreme Conditions
- Environmental Impacts of Oil and Natural Gas Development
- Enhanced and Unconventional Oil Recovery
- Resource Assessment

In addition, there will be a fifth area of activity where assessments will be done to identify and quantify the benefits that are expected to accrue as a result of the entire Section 999 Program, and to perform analyses in support of program planning.

The Complementary R&D Program Element has been designed to complement the R&D undetrtaken through the consortium-administered portion of the overall Section 999 program. For example:

- Within both the Environmental Impacts of Oil and Gas Development, and the Enhanced and Unconventional Oil Recovery centers there is a significant focus on oil shale and oil sands, resource areas that are not part of the consortium-administered portion of the program.
- The Center for Drilling Under Extreme Conditions will carry out fundamental research related to the performance of tools and equipment under extremely high pressures and temperatures, work that is complementary in that it is particularly related to development of the deep gas resource, which is not a target of the consortium program. At the same time, this work can be designed to support elements of the HPHT sour service themes under the Ultra-deepwater program element.
- The Center for Resource Assessment will develop data and analytical products that will be useful to both small producers and in the development of unconventional gas resources. These products, similar to those produced by DOE in the past and very popular within the industry, are not a focus area for the Consortium.

As the themes identified for Consortium-administered solicitations are translated into projects, continual communication between NETL and RPSEA will ensure that all program elements remain complementary and supportive and that duplication of effort is avoided.

Technology transfer for the entire Section 999 program will be a continually evolving function. Because the program currently does not have any active projects, the focus for this initial year is to release solicitations and establish R&D projects. Technology transfer will be an integral part of each RPSEA R&D award, as EPAct mandates that

each award recipient use 2.5% of their award for technology transfer, and for the NETL complementary R&D program. RPSEA and NETL have been working together to develop a technology transfer plan that meets the intent of the law and provides a systematic approach for development of an integrated technology transfer program. Also, RPSEA is required by their DOE contract to define their technology transfer approach in their Management and Communications Plans which are submitted annually to NETL for review and approval.

Section 999 sets the funding for the overall program at a level of $50-million-per-year over 10 years, provided from Federal lease royalties, rents, and bonuses paid by oil and gas companies. After allocations for program management by NETL and consortium R&D administration by RPSEA, the amounts to be distributed for R&D total $44.56 million ($32.06 million per year for consortium R&D and $12.5 million per year for complementary R&D).

Within NETL, the responsibility for overall program management has been assigned to the Strategic Center for Natural Gas and Oil (SCNGO). Complementary R&D will be carried out by NETL's Office of Research and Development (ORD). Planning and analysis related to the program, including benefits assessment and technology impacts analysis related to program direction, will be carried out by NETL's Office of Systems, Analysis and Planning (OSAP).

As required by Section 999, this Draft Annual Plan outlines the recommendations from the Consortium for consideration and comment by the Ultradeepwater Advisory Committee and the Unconventional Resources Technology Advisory Committee established under Section 999D(a) and Section 999D(b). The Plan includes the proposed complementary R&D to provide both of these committees with a comprehensive view of the entire Program.

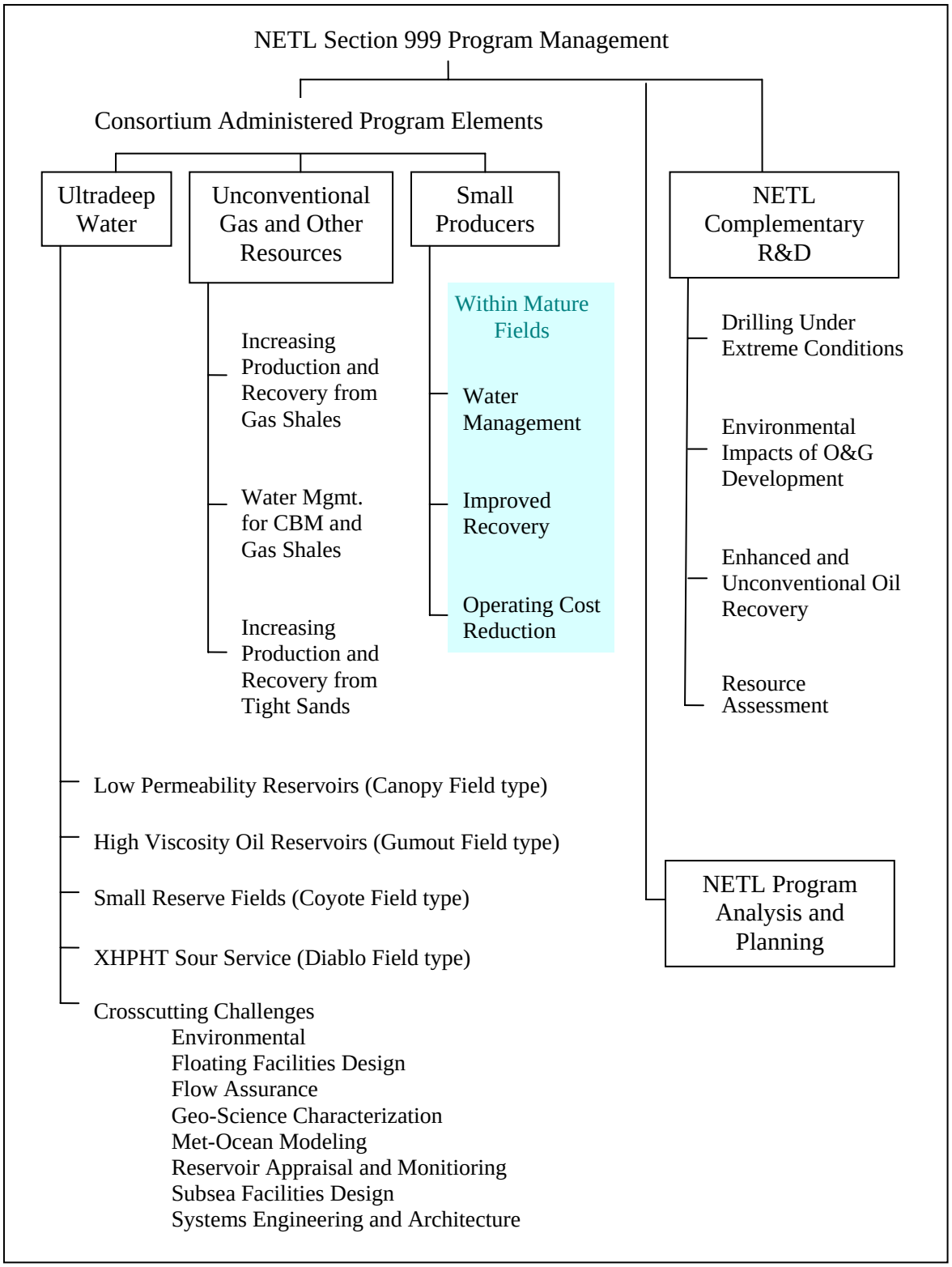


Figure 1: Section 999 Program Elements and Research Areas

Section 999 Area	Field / Resource Area	Technology Challenge	Themes
Ultradeepwater	*Canopy Field*	Low permeability reservoir	▪ Completion of long reservoir sections. ▪ Deep reservoir stimulation technology. ▪ Formation Integrity at Commercial Production Conditions.
	Gumout Field	High Viscosity Oil	▪ Intervention strategies and well architecture for downhole equipment maintenance (e.g., pumps). ▪ Viscous Oil Production Technology.
	Coyote Field	Small Reserve Fields	▪ Drilling with small margin between overburden and fracture pressure.
	Diablo Field	XHPHT Sour Service	▪ Materials Sciences for UDW Risers and Moorings, tubulars, tools, instrumentation, and completion equipment. ▪ HPHT Flow Assurance Technologies. ▪ HPHT Formation Evaluation.
	Crosscutting	Environmental	▪ Safety Barrier Testing and Validation Criteria. ▪ Environmental and Regulatory Impact of Emerging Technologies. ▪ Deepwater Produced Water Management.
		Floating Facilities	▪ Optimized UDW Field Development Concepts for Improved Economics. ▪ Improved Design and Analysis Methods. ▪ Mooring and Riser Integrity Management.
		Flow Assurance	▪ Organic, Inorganic and Solids Management.
		Geo-Science	▪ Subsalt Imaging & Geo-mechanics. ▪ Reservoir & Fluid Characterization. ▪ Economics.
		Met-ocean	▪ Effect of changing weather patterns on hurricane severity. ▪ Operational 3-D current forecast model capable of simulating the Loop/eddies. ▪ Modeling for strong near-bottom currents along the Sigsbee Escarpment.
		Reservoir	▪ Appraisal. ▪ Field development. ▪ Production and Reservoir Surveillance.
		Subsea Facilities	▪ Subsea Production Equipment Enhancements. ▪ Mature Subsea Processing Technology. ▪ Pipeline, Flowline and Umbilical Technology. ▪ Subsea Well Intervention Tech. improvement.
		Systems Engineering and Architecture	▪ Design Criteria for the Base Cases. ▪ System impact of proposed technologies on the field development scenarios. ▪ Grand Challenge projects ▪ Small Business Initiatives

Table 1: Ultradeepwater R&D Themes

Section 999 Area	Field / Resource Area	Technology Challenge	Themes
Unconventional Gas	*Gas Shales* Barnett Appalachian Permian Woodford-OK Trenton-Black River Permian-Woodford Green River	Rock Properties / Formation Evaluation	• Characterization of geologic, geochemical, geophysical, and operational parameters that differentiate high performing wells. • Development of methods to accurately assess the potential of a shale for gas production from common industry petrophysical measurements.
		Fluid Flow and Storage	• Development of methods to plan, model and predict the results of gas production operations • Accurate delineation of the natural fracture system for guiding horizontal wells to intersect a large number of open fractures
		Stimulation	• Development of extra-extended single and multi-lateral drilling/stimulation techniques. • Development of steerable hydraulic fractures. • Development of suitable low-cost fracturing fluids and proppants; e.g., non-damaging fluids and/or high strength low density proppants.
		Surface Footprint	• Develop advanced drilling, completion and/or stimulation methods that allow a greater volume of reservoir to be accessed from a single surface location and decrease the environmental impact
		Water Management	• Develop stimulation methods that require less water and other fluids to be injected into the subsurface. • Develop stimulation methods that result in a lower volume of treatment fluids produced to the surface. • Develop approaches for improved treatment, handling, re-use and disposal of fluids produced and/or used in field operations. • Extending the commercial life of a producing well through reduction of the initial drilling and completion costs, elimination of workovers and recompletions, as well as reduction of production costs particularly those associated with water disposal and management.
	Coalbed Methane Wyoming	Produced Water Management	• Develop methods for the treatment of produced water. • Develop methods for the sustainable beneficial use of produced water. • Develop methods to deal with produced water and control fines. • Develop techniques to minimize the volume of water produced to the surface. • Develop water management methods to reduce drilling and completion costs. • Develop technologies for effective development of multiple thin bed coal seams.
	Tight Sands Green River South Texas Uinta Deep Uinta Piceance Deep Piceance Western Oregon Washington	Sweet Spots / Formation Evaluation	• Characterization of geologic, geochemical, geophysical, and operational parameters that differentiate high performing wells
		Natural Fractures	• Accurate delineation of the natural fracture system for guiding horizontal wells to intersect a large number of open fractures.
		Wellbore - Reservoir Connectivity	• Development of extra-extended single and multi-lateral drilling techniques. • Development of steerable hydraulic fractures. • Development of suitable low-cost fracturing fluids and proppants; e.g., non-damaging fluids and/or high strength low density proppants.
		Surface Footprint	• Develop advanced drilling, completion and/or stimulation methods that allow a greater volume of reservoir to be accessed from a single surface location and decrease the environmental impact.
		Water Management	• Development of efficient and safe water management schemes. • Extending the commercial life of a producing well through reduction of initial drilling and completion costs, elimination of workovers and recompletions, as well as reduction of production costs, particularly those associated with water disposal and management.
Small Producers	Mature Fields	Increasing commercial production and ultimate recovery from established mature fields, including both currently producing and inactive fields	• Development of approaches and methods for water management, including produced water shutoff or minimization, treatment and disposal of produced water, fluid recovery, chemical treatments and minimizing water use for drilling and stimulation operations. • Development of methods for improving oil and gas recovery and/or extending the economic life of reservoirs. • Development of methods to reducing field operating costs, including reducing production related costs as well as costs associated with plugging and abandoning wells and well site remediation. Consideration will be given to those efforts directed at minimizing the environmental impact of future development activities. • Development of cost-effective intelligent well monitoring and reservoir modeling methods that provide operators the information required for efficient field operations. • Development of improved methods for well completions and recompletions, including methods of identifying bypassed pay behind pipe, deepening existing wells, and innovative methods for enhancing the volume of reservoir drained per well through fracturing, cost-effective multilaterals, in-fill drilling or other approaches. • Implementation and documentation of field tests of emerging technology that will provi operators with the information required to make sound investment decisions regarding t application of that technology. • Collection and organization of existing well and field data from multiple sources into a readily accessible and usable format that attracts additional investment.

Table 2: Unconventional Gas and Small Producer R&D Themes

1. Background

1.1 Energy Policy Act of 2005: Section 999

In August 2005, President Bush signed the Energy Policy Act (EPAct) into law; the first national energy plan in more than a decade. EPAct Sections 965, 968, and 999 all support oil and gas R&D. The first two of these sections relate to programs that DOE's Office of Fossil Energy and the National Energy Technology Laboratory (NETL) are already implementing. Section 999, however, adds a new dimension to the overall DOE oil and gas R&D effort, enhancing opportunities to demonstrate technologies in the field and accelerate their implementation in the marketplace. The complete text of Section 999 is included in Appendix A.

The Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Resources Program launched by Section 999 is a public/private partnership designed to increase America's domestic oil and gas supply and reduce dependency on imports. A portion of the funding is to be directed towards cost-shared research partnerships, while another portion is to be used by NETL to carry out complementary R&D.

EPAct Section 999 states, "The Secretary shall carry out a program of research, development, demonstration, and commercial application of technologies for ultra-deepwater and unconventional natural gas and other petroleum resource exploration and production to maximize the value of U.S. resources by increasing supply from these resources." The legislation identifies NETL as the DOE entity responsible for review and oversight of the resulting Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Resources Program. The legislation further states that "The Secretary shall contract with a corporation that is structured as a consortium to administer the programmatic activities …"

Section 999 sets the funding for this program at a level of $50-million-per-year over 10 years, provided from Federal lease royalties, rents, and bonuses paid by oil and gas companies. The funds are to be directed towards research specifically targeting four areas: ultra-deepwater resources, unconventional natural gas and other petroleum resources, technology challenges of small producers, and fundamental research complementary to these areas. The complementary research is to be performed by NETL, while all other research is to be administered by the consortium overseen by NETL. See Table 1.1 for breakdown of funding as directed by Section 999.

1.2 Overall Implementation Scheme

NETL is responsible for managing the Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Resources Program. Within NETL, the responsibility for overall program management has been assigned to the Strategic Center for Natural Gas and Oil (SCNGO). Complementary R&D will be carried out by NETL's Office of Research and Development (ORD). Planning and analysis related to the program, including benefits

assessment and technology impacts analysis related to program direction, will be carried out by NETL's Office of Systems, Analysis and Planning (OSAP).

A. Consortium Selection

In accordance with Section 999, and as ordered by the Secretary, NETL issued a competitive solicitation for a consortium to administer the research specified by the legislation. The Research Partnership to Secure Energy for America (RPSEA), a 501(c)(3) not-for-profit corporation consisting of over 100 member organizations, submitted a proposal and in May 2006 was selected by DOE to administer the distribution of about $32 million per year in R&D contracts (Table 1.1). The Federal Government will maintain management oversight of the program, and RPSEA's administration costs are limited to no more than 10 percent of the funds.

Area	Allocation	Area Funds	NETL Mgmt. 5%	RPSEA Admin. 10%	R&D Funds for Distribution
Ultra-deepwater	35%	17,500,000	875,000	1,662,500	14,962,500
Unconventional and Other	32.5%	16,250,000	812,500	1,543,750	13,893,750
Small Producers	7.5%	3,750,000	187,500	356,250	3,206,250
Consortium Total		37,500,000	1,875,000	3,562,500	**32,062,500**
Complementary	25%	12,500,000	0	0	12,500,000
Sec 999 Total	100%	50,000,000	1,875,000	3,562,500	44,562,500

Table 1.1: Distribution of Funds as Directed by Section 999 (US$)

RPSEA has a broad membership base that includes representatives from all levels and sectors of both the oil and gas E&P and oil and gas R&D communities (see Appendix B). Roughly 16 percent of the RPSEA membership is made up of smaller oil and gas producers, 5 percent are large producing companies, 23 percent are universities, 26 percent are technology development companies of all sizes, and 9 percent are national labs or research institutes. This breadth of membership will help ensure that consortium-administered R&D funds are directed towards key problems in ways that leverage existing industry efforts. A variety of advisory committees drawn from this membership will also be incorporated into RPSEA's planning process, as well as in the selection of R&D projects and the review of project results.

The industry consortium approach will enhance the overall program in other ways as well. The companies, universities, and other organizations that receive funds through this program will provide cost-share contributions of at least 20 percent of total project costs, magnifying the impact of the public investment. The inclusion of universities and other research institutions in this program will help to ensure the continued development of America's intellectual capital, particularly in areas of engineering, geophysics, materials science, and other basic sciences. Finally, the wider involvement of industry partners in

all phases of the oil and gas R&D process will dramatically increase the likelihood of near-term demonstrations of technologies developed by the program, a key step in accelerating the movement of these technologies into the marketplace.

B. Planning Process

In late 2006 NETL awarded the contract for RPSEA to begin its work with an effective date of January 4, 2007. RPSEA immediately began preparing its first Draft Annual Plan, which was submitted to DOE on April 3, 2007. That RPSEA Draft Annual Plan, as received, is attached as Appendix C. Key elements of that draft and the recommendations in it have been incorporated into Section 2 of this document, with some modification.

Also in late 2006, NETL began a process to develop a plan for carrying out the complementary research specified by Section 999, as well as a management and oversight plan for overseeing both the consortium and the complementary in-house R&D activities. The results of this effort are incorporated into Section 3 of this document.

This Draft Annual Plan, incorporating both the consortium-administered and complementary in-house research program elements, must be approved by the Secretary of Energy before the solicitation of R&D project proposals can begin. Prior to submitting the Plan to the Secretary, the legislation calls for DOE to gather input on the Draft Annual Plan from two Federal advisory committees formed by DOE, as well as from other industry experts. These two committees are the Ultra-Deepwater Advisory Committee and the Unconventional Resources Technology Advisory Committee. DOE's Office of Fossil Energy is responsible for organizing both of these committees. This approach is designed to bring together a broad range of intellect, to ensure that the program of research undertaken returns the maximum benefit to the Nation in terms of domestic oil and gas supply increase. The comments received from these advisory committees are included in Appendix D, along with a description of the actions taken in response.

Upon his approval of the Draft Annual Plan, the Secretary of Energy must transmit the plan to Congress, along with the recommendations of the consortium and the advisory committees.

Subsequent years' Draft Annual Plans must include details of ongoing activities, a list of solicitations (including topics of R&D, selection criteria, duration of awards, and anticipated funds), a list of awards made, and an estimate of the cumulative increase in Federal royalties that can be expected from the ultimate application of the results.

C. RPSEA Structure and Consortium Plan Development

Key features of RPSEA's organization are illustrated in Figure 1.1. The make up of the Board of Directors (BOD) and the external advisory committees and groups are provided in Appendix B, and their respective roles are described below:

Board of Directors (BOD) - In addition to operational oversight, the BOD provides significant input and direction to the preparation of the RPSEA Draft Annual Plan.

Strategic Advisory Committee (SAC) - RPSEA established the Strategic Advisory Committee (SAC) to provide strategic direction, advice on the shape of the research portfolio, long range planning recommendations, and metrics determination to the BOD and to the President. The SAC is comprised of a group of industry leaders in the energy field, including both RPSEA members and non RPSEA members. The SAC provided guidance regarding the process used to develop the RPSEA Plan, the proposed R&D portfolio, and the metrics to be used to track progress toward program goals.

Environmental Advisory Group (EAG) - The Environmental Advisory Group (EAG) is designed to provide all program elements with advice regarding environmental issues.

Program Advisory (PACs) and Technical Advisory (TACs) Committees - The roles of the PACs and the TACs are described in Section 2 of this document, as they are specific to their program element. Generally, the PACs provide recommendations on elements of the proposed plan, review proposals and recommend project selections. The TACs provide subject specific technical advice on the development of the proposed plan and on proposal reviews at the direction of the PACs.

Small Producers Research Advisory Group (RAG) - The Small Producer program element will receive guidance from a Small Producer Research Advisory Group (RAG) consisting of industry and academic representatives that are closely tied to the national small producer community. The RAG will follow each project's progress, plans and results and especially technology transfer. All projects will be reviewed by the RAG semi-annually.

While the RAG will be responsible for directing the Small Producer program, the Unconventional Onshore PAC will remain responsible for oversight of the entire onshore program, which includes the small producer program element.

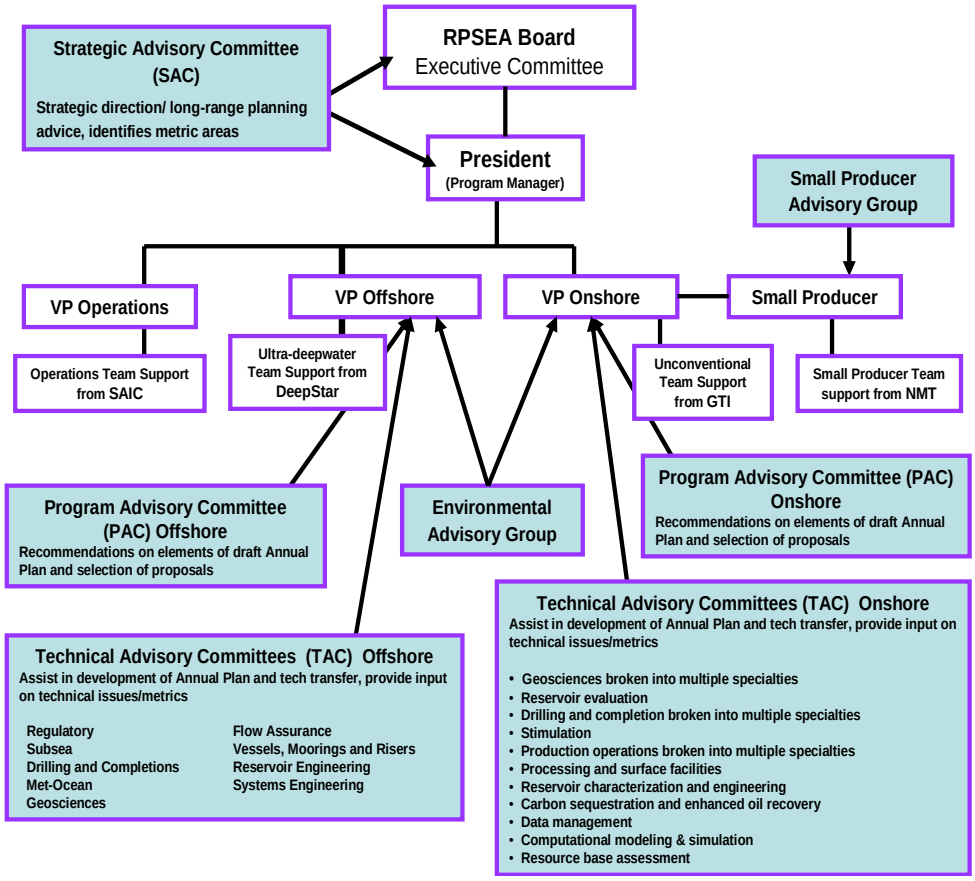


Figure 1.1: Organization of RPSEA and Advisory Committee Relationships

RPSEA has been operating as a consortium for almost 5 years. Additionally, RPSEA has contracted with four organizations, the Chevron adminstered DeepStar Consortium (DeepStar), Gas Technology Institute (GTI), SAIC, and New Mexico Tech University (NMT), as its management team.

During development of its draft annual plan RPSEA received input from its member organizations as well as from a broad spectrum of additional experts. Input was solicited and/or developed from:

- 11 RPSEA Member Forums held in various regions of the country. While RPSEA members hosted the forums, participation was not limited to RPSEA members. Member Forums included 613 individual participants representing 193 organizations with interests in technologies to enhance domestic natural gas and oil production.
- The Academic Community. Universities served as hosts of all the RPSEA Member Forums. Nearly 50 individuals representing over a dozen universities have registered or participated in TAC meetings, and universities are represented on the Unconventional Onshore PAC.
- Multiple individual meetings and contacts with individual RPSEA members.

- RPSEA's Offshore and Onshore PACs and the Small Producer RAG for general guidance, the various Technology Advisory Committees, and the Strategic Advisory Committee.
- Multiple roadmapping exercises conducted by DOE, RPSEA, and others prior to 2007.

The process on integrating these inputs is illustrated in the schematic shown in Figure 1.2.

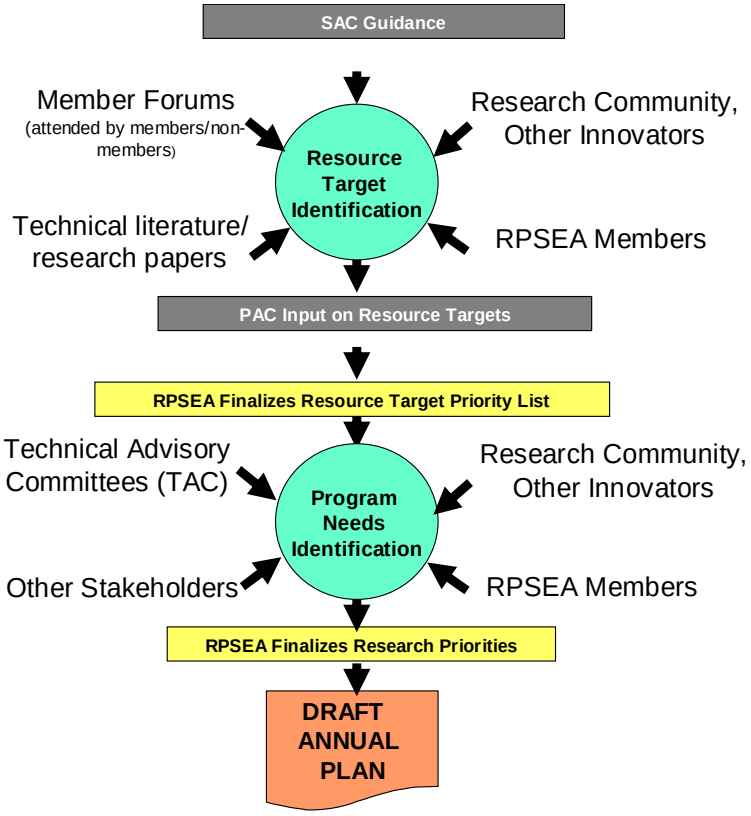


Figure 1.2: Process Leading to RPSEA Draft Annual Plan

2. Consortium R&D Plan

The Section 999 statute specifies that the Consortium selected by the Department of Energy is to administer a program of research, development, demonstration and commercialization in three of the nation's most promising—but technically challenged—natural gas and petroleum resource areas:

- ***ultra-deepwater*** (UDW) areas of the Outer Continental Shelf,
- ***unconventional natural gas and other petroleum resources***, with unconventional being defined as "economically inaccessible," and
- the unique ***technology challenges of small independent producers***.

Further, cross-cutting all elements of the program is a focus on the environment, including projects that minimize or mitigate environmental impact or risk, mitigate water usage, reduce the "footprint," of E&P operations and lower emissions.

Each of these three Program Elements is individually outlined in the plan that follows.

2.1 Ultra-deepwater Program Element

A. Mission

The mission of the Ultra-Deepwater (UDW) element of the consortium-administered R&D program is to identify and develop economically viable (full life cycle), acceptable risk technologies, architectures, and methods to explore, drill and produce hydrocarbons from UDW and formations in the Outer Continental Shelf (OCS) deeper than 15,000 feet.

This mission of technology development encompasses:

- *Extending basic scientific understanding,*
- *Developing "enabling" technologies,*
- *Enhancing existing technologies to help lower overall cost and risks, and*
- *Pursuing "Grand Challenges"* (transformational technologies which, if successfully developed, are capable of "leapfrogging" over conventional pathways).

Relevant EPACT definitions for the UDW program element include:

- *Deepwater* -- a water depth that is greater than 200 but less than 1,500 meters.
- *Ultra-deepwater* -- a water depth that is equal to or greater than 1,500 meters.
- *Ultra-deepwater architecture* -- the integration of technologies for the exploration for, or production of, natural gas or other petroleum resources located at UDW depths.
- *Ultra-deepwater technology* -- a discrete technology that is specially suited to address one or more challenges associated with the exploration for, or production of, natural gas or other petroleum resources located at UDW depths.

B. Goals

The goals of the UDW program element are to increase the size of the UDW resource base and to convert currently identified (discovered) resources into economic recoverable (proven) reserves while protecting the environment, thereby providing the U.S. consumer with secure and affordable petroleum supplies. These goals will be achieved by:

1. Reducing the costs to find, develop and produce such resources,
2. Increasing the efficiency of exploration for such resources,
3. Increasing production efficiency and ultimate recovery of such resources,
4. Improving safety, and
5. Improving environmental performance, by reducing any environmental impacts associated with UDW exploration and production.

This goal has been quantified through two targets described in Table 2.1. These targets are to be achieved within the 2007-2017 time frame.

Goal	Target Metric
Through new technology development and dissemination increase the size of the UDW resource base.	The 2000 MMS Assessment indicated that more than 50 billion recoverable BOE remains to be discovered. The goal over the course of the program is to develop the technologies required to help identify and discover 1% or more (1% is the equivalent of one 500 MMBOE field or five 100 MMBOE fields) of this potential. At current commodity prices this goal would be valued in excess of $30 billion. Achievement of this goal would mean over a 200:1 return on investment.
Convert currently identified (discovered) resources into economic recoverable (proven) reserves	The MMS 2006-022 Report identifies a gap of 9 BBOE between proven reserves and the discovered resource base (Figure 2.1). The program goal is to add 100 MMBOE and more to the technically recoverable resource. At current commodity prices this goal would be valued in excess of $6 billion, roughly a more than 40:1 return on Program investment (additive to the target metric above).

Table 2.1: Goals and Target Metrics for the UDW Program

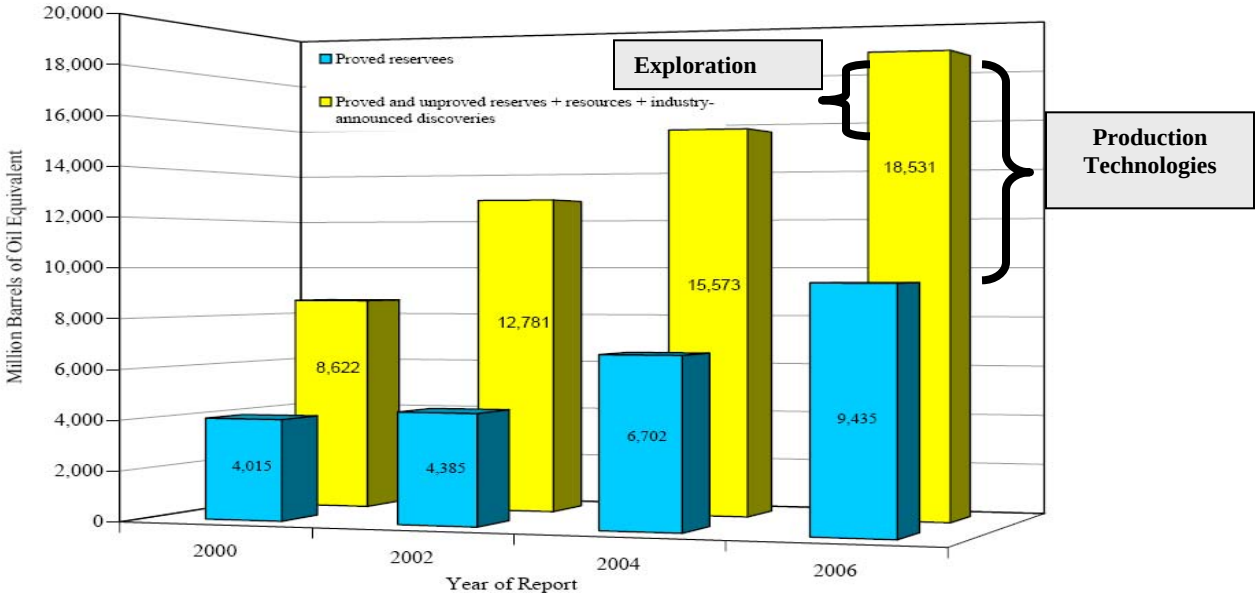


Figure 2.1: Illustration of increases in proved reserves and discovered volumes of deepwater hydrocarbons since 2000 (MMS 2006-022 Report, Figure 78). Exploration technologies have resulted in 3 billion BOE additional resource between 2004 and 2006, while the target for new production technologies designed to move discovered resource to proven reserves, has grown to 9 BBOE.

C. Objectives

In the final analysis, to meet the goals of converting the UDW resource base to economically recoverable reserves, new planning and analytical models must be built; new equipment must be designed and manufactured; the equipment must then be demonstrated to be dependable and reliable, and ultimately manufactured and deployed in commercial quantities. This will be achieved by meeting the following near term, mid term and long term objectives.

Near-Term (2007-2008)

Objective #1: *Technology Needs Assessment* – Complete the ongoing process to identify and prioritize the specific technologies that carry the greatest potential for adding to the UDW reserve base and report results and conclusions.

Objective #2: *Cost-Share Development* – Network with academia, industry, capital markets and other key stakeholders to identify and capture cost-share funding for development of new technologies and report recommendations.

Objective #3: *Ultra-Deepwater Technology Development* – Design and administer multiple rounds of solicitations for R&D contracts designed to meet the stated goal of the UDW program element. Successfully administer a selection process that results in a portfolio of R&D contracts that will best achieve that goal.

Mid-Term (2007-2012)

Objective #4: *Ultra-Deepwater Technology Development and Deployment* – Through assessment of R&D results and additional solicitations (as needed), continue the development and maturation of the most promising technologies identified during the first round of solicitations. Maintain a strong focus on deployment and commercialization. Terminate weaker prospects and focus budget and efforts on those technologies that carry the greatest potential for meeting the UDW program element goal.

Objective #5: *Environmental Technology Development and Deployment* – Work with appropriate regulatory agencies, academia, industry and other key stakeholders to identify strategies to improve environmental performance during deepwater development, and develop and administer solicitations for contracts to develop technologies that can achieve this improvement.

Objective #6: *Safety Technology Development and Deployment* – Work with appropriate regulatory agencies, academia, industry and other key stakeholders to identify strategies to improve safety performance during deepwater development, and develop and administer solicitations for contracts to develop technologies that can achieve this improvement.

Long-Term (2007-2017)

Objective #7: *Technology Demonstration* – Work with industry, appropriate regulatory agencies and other key stakeholders to provide seed-level funding and other incentives for demonstration and validation of newly developed technologies.

Objective #8: *Technology Commercialization* – Work with industry, appropriate regulatory agencies and other key stakeholders to provide seed-level funding and other incentives to ensure commercialization of emerging technologies.

D. Implementation Plan

The UDW program element will be implemented in a different manner than the other two parts of the consortium-administered program (Unconventional Resources and Small Producer elements) which focus on broader research topics. EPACT states the UDW program element "*shall focus on the development and demonstration of individual exploration and production technologies as well as integrated systems technologies including new archectures for production in ultra-deepwater.*" RPSEA has subcontracted management of the UDW program element to a third party, who already has a successful process developed and operating. The following section outlines the major steps in the implementation plan.

DeepStar and Advisory Committee Roles in UDW Program Element

The UDW Program Element will be managed by the Chevron administered DeepStar Consortium through a subcontract with RPSEA. DeepStar is the world's largest UDW stakeholders group and has a 15 year history of managing collaborative research. Through this arrangement, the UDW program will have access to 700+ technical and

management committee volunteers as well as a successful process for technology research, development, and commercialization. In addition to providing high level input from operating companies that are ultimately responsible for the production of deepwater energy resources, this highly developed process formally facilitates the direct input of universities, regulatory bodies and other key stake holder groups. This process of broad engagement through expansive and inclusive advisory committees will provide the UDW Program with significant *pro bono* expertise as well as potentially significant matching funds to further accelerate the development of UDW technologies.

DeepStar will be assisted in carrying out its subcontract by the UDW Program Advisory Committee (PAC) and nine Technical Advisory Committees (TACs) (see Appendix C for committee membership). The UDW PAC members represent asset owners that are currently operating in the UDW Gulf of Mexico. The UDW PAC provides high level input on program priorities, field areas of interest, and technology dissemination, as well as a link to the producer and research communities, but its primary role is project selection. PAC engagement in the process is critical as these operators will be the organizations called upon to actually deploy and operate the new technologies developed under the program.

Supporting the PAC are nine TACs, each of which is focused on a particular UDW technology area (Table 2.2). The role of the TACs, with representation from Subject Matter Experts who study and apply UDW technologies in real field situations, is to identify current technology gaps and define the specific R&D efforts needed to address these gaps. As such, the TACs provide a bottom-up end-user-driven program.

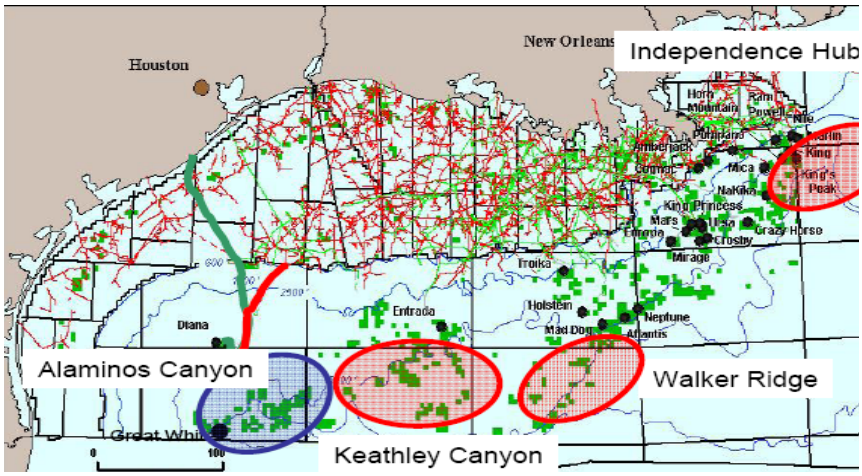
Drilling & Completion	Environmental, Safety & Regulatory	Floating Facilities
Flow Assurance	Geo-Science	Met-Ocean
Reservoir	Subsea Facilities	System Engineering & Architecture

Table 2.2: UDW Technical Advisory Committees

Identification of Focus Areas for New Technology Development

In developing the list of focus areas for solicitations, a systems engineering study was performed based on industry experience in deepwater areas. From this, four base case field development scenarios were identified which were considered to be representative of those future Gulf of Mexico UDW developments that will have the greatest need of enabling technologies to overcome technical barriers. These scenarios are drawn from four key areas of activity in the deepwater Gulf of Mexico (Walker Ridge, Keathley Canyon, Alaminos Canyon and the Eastern Gulf), and the technology challenges identified with those areas (Figure 2.2). These scenarios, are represented by four generic fields (Canopy, Gumout, Coyote and Diablo), each of which display a unique design feature that challenges technical and economic development (Table 2.3). In several of these scenarios, near term technology is available and is pending field qualification. It is

envisioned that such technologies could be matured under the UDW Program Element, enabling or enhancing their deployment and demonstration.



Walker Ridge / Keathley Canyon
- sub-salt
- deeper wells
- tight formations

Alaminos Canyon
- viscous crude
- lacking infrastructure

Eastern Gulf – Gas Independence Hub
- higher pressure & temp.
- CO_2 / H_2S

Overall
- higher drilling costs
- challenging economics

Figure 2.2: Technical challenges for identified basins

Table 2.3: UDW Base Case Scenarios

Field Type	Technology Challenge	Development Options
Canopy Field	Low Permeability Reservoir	Semi with Wet Trees
		FPSO with Wet Trees
		FPSO EPS
		Produce to Beach
Gumout Field	High Viscosity Oil	Dry Tree Structure
		Satellite Tieback to Host
Coyote Field	Small Reserve Fields	Satellite Tieback to Host
Diablo Field	XHPHT (22.5 ksi x 350+°F)	Semi w/ Gas Sweetening
		Produce to Beach thru Sour Gas Pipeline

Prioritization of Technology Development Needs

The nine TACs reviewed these four base case scenarios and, for their respective disciplines, identified the highest priority technology "themes" required to bridge the technology challenges that are barriers to development. These themes are listed in Table 2.4. Because each of the four base case scenarios represents a complete field development, a number of the themes identified are either multi-disciplinary or cut across several TAC discipline areas. Accordingly, the themes have been categorized either by specific base case or crosscutting, with the crosscutting section further categorized by

technology challenge. The themes in the table have been initially grouped into three solicitations: Solicitation 1 (S1), Solicitation 2 (S2), or Solicitation 3 (S3). This initial grouping was necessary to provide more focus for the solicitation process. The solicitation grouping may change as more discussion and external input is provided. Additional detail on these themes and the prioritization process can be found in pages 24-36 of the attachement of Appendix C.

Project Development to Address Prioritized Technology Themes

The next step will be for the UDW TACs to further refine the themes listed in Table 2.4 into specific technology projects. This refinement process (currently underway) is based on the development of proposed project ideas to address particular themes. Project ideas can be proposed by the TACs themselves or by any interested/knowledgeable entity. A key aspect of this process is the inclusion of a "UDW operator Champion" for each proposed project idea which helps to ensure alignment from idea to actual implementation in the UDW program.

The proposed project ideas are subjected to a review by the broader TAC, which then refines the Scope of Work, identifies deliverables, and estimates the schedule and costs. The proposed project ideas are then ranked by the respective TACs. Each TAC then submits their ranked project ideas to the PAC. The PAC will then evaluate and prioritize the project ideas from all TACs. This PAC prioritization will be based on projected project impact, available budget and alignment with overall Program Goals.

Development of Solicitations

Each of the top-ranked proposed project ideas as discussed above will be converted by RPSEA into a Request for Proposal (RFP). These RFPs will then be separated into the three Solicitations identified in Table 2.4 according to the plan below:

- 1st solicitation (immediately following Plan approval) where Priority 1 themes will be addressed,
- 2nd solicitation (4 months after Plan approval) where Priority 1 & 2 themes will be addressed, and
- 3rd solicitation (7 months after Plan approval) where all themes may be addressed, dependent upon available funding.

The solicitations will be advertised nationally through multiple media outlets for a minimum period of 45 days (see Section 2.4 for further details on the solicitation process).

Field Type / Focus Areas	Technology Challenge	Themes (more details on these themes can be found in Appendix C, pages 24-36)
Canopy Field	**Low permeability reservoir**	1. Completion of long reservoir sections. (S3) 2. Deep reservoir stimulation technology. (S2) 3. Formation Integrity at Commercial Production Conditions (fluid rates, differential pressures). (S3)
Gumout Field	**High Viscosity Oil**	4. Intervention strategies and well architecture for downhole equipment maintenance (e.g., pumps). (S1) 5. Viscous Oil Production Technology. (S2)
Coyote Field	**Small Reserve Fields**	6. Drilling with small margin between overburden and fracture pressure (dual density drilling is a potential solution for this issue). (S2)
Diablo Field	**XHPHT (22.5 ksi & 350+°F) Sour service**	7. Materials Sciences for UDW Risers and Moorings, tubulars, tools, instrumentation, and completion equipment. (S2) 8. HPHT Flow Assurance Technologies. (S1) 9. HPHT Formation Evaluation. (S2)
Crosscutting	**Environmental**	10. Safety Barrier Testing and Validation Criteria. (S1) 11. Environmental and Regulatory Impact of Emerging Technologies. (S2) 12. Deepwater Produced Water Management. (S2)
	Floating Facilities	13. Optimized UDW Field Development Concepts for Improved Economics. (S1) 14. Improved Design and Analysis Methods. (S1) 15. Mooring and Riser Integrity Management. (S1)
	Flow Assurance	16. Organic, Inorganic and Solids Management. (S1)
	Geo-Science	17. Subsalt Imaging & Geo-mechanics. (S1) 18. Reservoir & Fluid Characterization. (S2) 19. Economics. (S3)
	Met-ocean	20. Effect of changing weather patterns on hurricane severity. (S2) 21. Operational 3-D current forecast model capable of simulating the Loop/eddies. (S1) 22. Modeling for strong near-bottom currents along the Sigsbee Escarpment. (S3)
	Reservoir	23. Appraisal. (S1) 24. Field development. (S2) 25. Production and Reservoir Surveillance. (S2)
	Subsea Facilities	26. Subsea Production Equipment Enhancements. (S1) 27. Mature Subsea Processing Technology. (S1) 28. Pipeline, Flowline and Umbilical Technology. (S2) 29. Subsea Well Intervention Tech. improvement. (S1)
	Systems Engineering and Architecture	30. Design Criteria for the Base Cases. (S1) 31. System impact of proposed technologies on the field development scenarios. (S2) 32. Grand Challenge projects (S1) 33. Small Business Initiatives (S1)

Table 2.4: UDW Program Element Technology Themes (S1 to S3 Solicitation)

Funds Available and Anticipated Awards
The UDW Program will have $14.96 million per year available for project awards. It is anticipated that the UDW Program Element, in the initial year, will award 5-30 projects ranging from $250K to $3 MM having an average Federal government contribution of $750K and a project period of 1-3 years.

E. Metrics

The goals of the UDW program element are to increase the size of the UDW resource base and to convert currently identified (discovered) resources into economic recoverable reserves while protecting the environment, thereby providing the U.S. consumer with secure and affordable petroleum supplies. The long term metrics for this program element and the Consortium in general are discussed in Section 2.5.

Shorter-term metrics include the completion of annual milestones that show progress towards meeting the program element objectives. As a minimum, short term metrics for the end of FY 2007 through FY 2008 shall include:

- Prioritize Proposed Projects
- Issue 2-3 solicitations.
- Select and award a minimum of 5 projects.
- Establish FY 2009 R&D priorities based on results of 2007-08 solicitations and inputs from the TACs and PAC.

In addition, the UDW Program will continue to acquire and analyze the data necessary to accurately quantify base case and post technology application case assessments of proved and unproved reserves in order to accurately quantify the incremental reserves attributable to specific program-developed technologies. These assessments will include estimates of the value of goods and services created from the products developed by this program element. In addition, the program will continue to acquire data to validate/calibrate the MMS Assessment of remaining discoverable, recoverable resources. Determination of the UDW program benefits will be fully coordinated with NETL's Office of Systems, Analysis and Planning.

F. Milestones

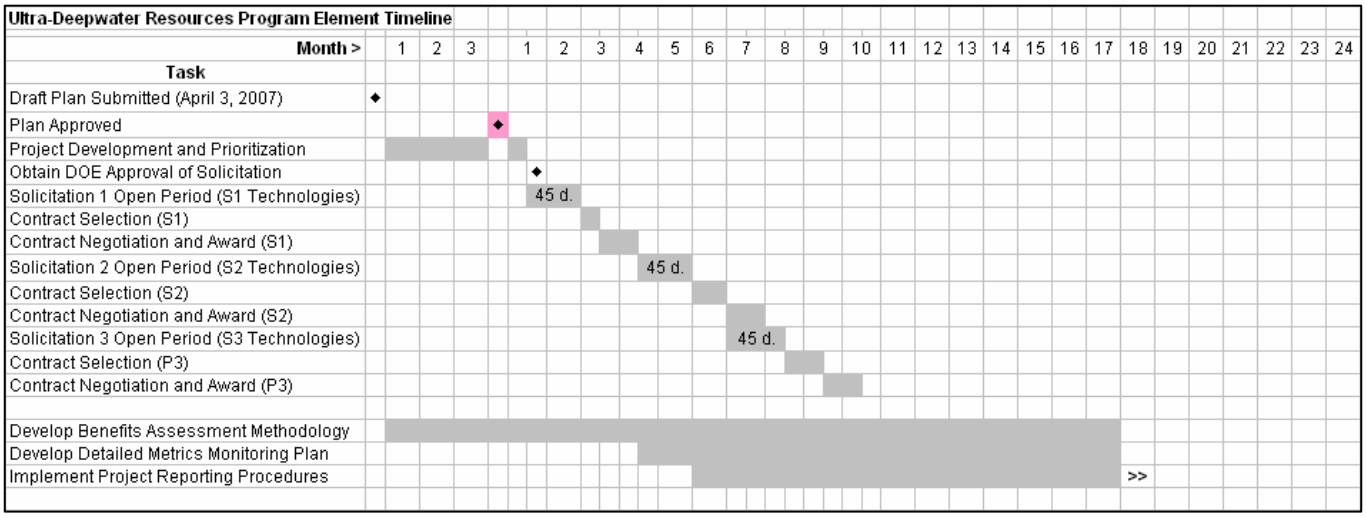
The first Solicitation will be conducted within three weeks after approval of the Annual Plan, and will remain open for 45 days (see Table 2.5 The review selection and award process will take no longer than two and one half months. A second solicitation will be released 4 months after plan approval, with a third solicitation planned for 7 months after plan approval dependent upon funding availability.

The following steps are represented on the timeline:

1. Draft Annual Plan Submittal (completed)
2. Technology Theme Refinement
   Report justifying rationale for theme selection and final prioritization

3. Annual Plan Approval
4. Project Development and Prioritization (underway)
5. Obtain DOE approval of Solicitation
6. Solicitation 1
    - Solicitation Open Period
    - Proposal Evaluation and Selection
    - DOE Approval of Selections
    - Contract Award
7. Solicitation 2
    - Solicitation Open Period
    - Proposal Evaluation and Selection
    - DOE Approval of Selections
    - Contract Award
8. Solicitation 3 (if warranted)
    - Solicitation Open Period
    - Proposal Evaluation and Selection
    - DOE Approval of Selections
    - Contract Award
9. Develop and apply methodology for quantifying benefits as a result of the application of program-developed enabling technologies.
10. Establish FY2009 R&D priorities based on results of 2007-08 solicitations, inputs from the program advisory committees, and modeling of the impacts of various R&D applications.
11. Monitor progress of all awards and make any necessary adjustments to research plans.
12. Satisfactorily report all program deliverables to NETL.

Table 2.5: UDW Program Element Timeline



2.2 Unconventional Natural Gas and Other Petroleum Resources Program Element

A. Mission

The mission of the Unconventional Resources element of the consortium-administered R&D program is to identify and develop economically viable technologies to locate, characterize and produce unconventional natural gas and other petroleum resources, in an environmentally acceptable manner.

"Unconventional natural gas and other petroleum resource" is defined in EPACT as *natural gas and other petroleum resource located onshore in an economically inaccessible geological formation, including the resources of small producers.*

B. Goal

The overall goal of the Unconventional Resources program element is to increase the supply of domestic natural gas and other petroleum resources through the development, demonstration and commercialization of technologies that reduce the cost and increase the efficiency of exploration for and production of such resources, while improving safety and minimizing environmental impact.

The contribution of natural gas to the Nation's gas supply from three specific unconventional resources—gas shales, coal seams, and tight sands—has grown significantly during the past 20 years. These resources have been highlighted by the Energy Information Administration (EIA) and others as critical supply sources during the next 20 years. According to the latest estimate by the National Petroleum Council (NPC 2003) the volume of technically recoverable gas from these three resources in the lower 48 states is in excess of 293 trillion cubic feet (TCF). Due to their potential and critical significance, gas shales, tight gas sands and coalbed methane were determined to be the only unconventional resources to be addressed in this initial Plan. Other unconventional natural gas and petroleum resources may be addressed in subsequent years, should funding be extended under EPACT or other legislation.

This goal has been quantified through two targets described in Table 2.6. These targets are to be achieved within the 2007-2017 timeframe.

Goal	Target Metric
Through new technology development and dissemination increase the size of the technically recoverable unconventional resource.	The NPC 2003 technically recoverable unconventional resource base is currently 293 TCF. This number, as with the overall resource base, has grown in magnitude in past years due to new technology applications. A goal of the program is to add 30 TCF to the technically recoverable unconventional resource.
Convert technically recoverable resources into economic recoverable (proven) reserves	The technically recoverable unconventional resource base is currently 293 TCF. None of this resource is currently economic, but can be made so through the development and application of new technology that drives down the cost and environmental impact of development of this reserve base. A goal of this program is to convert 10 TCF of unconventional gas resource from technically recoverable to economic reserves. It should be noted that both of these target metrics are closely related in how they will be achieved and are additive.

Table 2.6: Goals and Target Metrics for the Unconventional Gas and Other Petroleum Resources Program

C. Objectives

Objectives for the Unconventional Resources program element have been developed with input from the Consortium's unconventional onshore Program Advisory Committee (PAC). This input has been combined with information gathered during a number of relatively recent efforts to identify and prioritize the technology challenges to development of unconventional resources. These efforts include: 1) a series of five workshops held in various producing basins by RPSEA and New Mexico Tech during 2003, 2) workshops carried out as part of the National Petroleum Council (NPC) 2003 Natural Gas Study, 3) a series of DOE-sponsored unconventional gas technology road-mapping workshops held during 2005, 4) eleven forums held by RPSEA during late 2006 and early 2007, and 5) information developed for the yet-to-be published NPC Global Oil and Gas Study in 2006 and 2007. All of these inputs were combined to arrive at the prioritized list of technology challenges that underlie both the objectives of this program element and the list of solicitation topics found in the implementation plan.

The objectives are defined in terms of the resource (shales, coal, tight sands), and the level of field development category (existing, emerging and frontier). All three resources are important but gas shales, the most difficult and least developed, was identified during this process as the top priority. It was the consensus of the advisory groups that gas

shales promised the greatest potential return on investment in terms of reserves additions (see pages 50-53 of attachement in Appendix C). The three development categories are:

- Existing - Active development drilling and production
- Emerging - Formations, depth intervals, or geographic areas from which there has been limited commercial development activity and very large areas remain undeveloped.
- Frontier Area - Formations, depth intervals, or geographic areas from which there has been no prior commercial development.

The relative balance of the program's focus amongst these three categories, as well as the priority plays/basins identified within each of the three resource areas, are illustrated within Table 2.7. The basins noted are representative based on expressed industry interest and not meant to exclude opportunities in other basins within the three resource types.

Level of Field Development	Program Balance	Priority Gas Shales	Priority Coalbed Methane	Priority Tight Sands
Existing	45%	Ft Worth - Barnett	Appalachian	Green River/Uinta
		Appalachian	San Juan	South Texas
			Powder River	Appalachian
Emerging	45%	Permian	Uinta-Piceance	Appalachian
		Arkoma/Ardmore/Anadarko	Powder River	Piceance
		Illinois & Michigan		Uinta
Frontier Area	10%	Permian-Woodford	Illinois & Michigan	Western Oregon
		Green River	N. Mid-continent	Washington

Table 2.7: Resource and Play Type Prioritization Matrix

In the near-term, the primary challenge facing gas producers is the rapid depletion rate of new wells and their relatively high cost. Rapid decline rates require that many new wells be drilled just to maintain production. To address these concerns, R&D activities associated with the near term will have a significant field-based component with supporting analytic work. Methods and techniques developed in this phase will be tested in the field through industry cooperative field work. This near-term research and development will be built on recent technology successes in advancing these technologies to a higher level and broadly disseminating the results. Near term projects will primarily focus on field testing, technology dissemination and commercialization.

In the mid-term, program emphasis again will be placed on industry cooperative field work in emerging areas. Working models developed through the near term program will be applied in less developed fields, modified as required, and documented to make the technology readily available to the industry. The focus of the mid-term research will be the development of at least one new emerging resource area to the point where a substantial portion of the technical resource becomes economic reserves.

In the long-term, the program aims at identification and characterization of two or more resource-rich plays or basins with limited current activity. The objective will be to provide information, knowledge, and methodologies to spur activity in currently undeveloped and low activity resources, allowing access to gas that is technically not feasible to drill and produce with current technologies.

Specifically, the objectives of the Unconventional Resources program element are:

Near term (2007-2010)
Objective 1: Develop tools, techniques and methods that substantially increase, in an environmentally sound manner, commercial production and ultimate recovery from high priority existing and emerging established gas shale formations.

Objective 2: Develop tools, techniques and methods that substantially decrease the environmental impact of produced and used water associated with coalbed methane and gas shale development. And secondarily, develop tools, techniques and methhods to improve production from coalbed methane reservoirs within high priority existing and emerging plays.

Objective 3: Develop tools, techniques and methods that increase commercial production and ultimate recovery from established tight gas sand formations and accelerate development of existing and emerging tight gas sands plays.

Mid-Term (2007-2012)
Objective 4: Develop techniques and methods for exploration and production from high priority emerging gas shale, coal and tight sand plays where these operations have been hindered by technical, economic or environmental challenges.

Long-Term (2007-2017)
Objective 5: Develop techniques and methods for exploration and production from frontier area basins and formations where these operations have been hindered by technical, economic or environmental challenges.

D. Implementation Plan

The Unconventional Resource program element will be implemented by developing and administering solicitations for R&D projects in areas that address the objectives outlined above. The following section outlines the major steps in the implementation plan.

Development of Solicitations to Address Prioritized Technology Challenges

The first solicitation in 2007 will concentrate on three areas of interest: Gas Shales, Water Management in Coalbed Methane and Gas Shales, and Tight Sands; all in existing and emerging areas. Proposals in the Frontier area will get consideration for selection if compelling impact can be demonstrated, however those will not be the main focus. The selections will be dependent on the quality of proposals received. Subsequent 2008 solicitations will be designed to fill-in the gaps that the 2007 solicitation left open. As the

R&D program gets underway in a particular region or resource area, RPSEA anticipates that R&D issues not initially identified may develop resulting in the need for additional solicitations.

As the program is initiated, early solicitations will be broad in scope, allowing a broad range of research topics addressing key issues to be considered. The Scope for each of the areas of interest for the initial planned solicitation is summarized below. A more complete description of the solicitation process is included in Section 2.4 of this report. As the program matures, subsequent solicitations will address more detailed and specific problems, building on earlier program successes.

Area of Interest 1: Gas Shale
Scope: The solicitation will request ideas and projects for development of tools, techniques and methods that may be applied to substantially increase, in an environmentally sound manner, commercial production and ultimate recovery from the established gas shale formations and accelerate development of emerging and frontier gas shale plays. The concepts may include but will not be limited to the following areas:

- Characterization of geologic, geochemical, geophysical, and operational parameters that differentiate high performing wells.
- Development of methods to accurately assess the potential of shale for gas production from common industry petrophysical measurements.
- Development of methods to plan, model and predict the results of gas production operations.
- Accurate delineation of the natural fracture system for guiding horizontal wells to intersect a large number of open fractures.
- Development of extra-extended single and multi-lateral drilling techniques.
- Development of steerable hydraulic fractures.
- Development of suitable low-cost fracturing fluids and proppants; e.g., non-damaging fluids and/or high strength low density proppants.
- Develop advanced drilling, completion and/or stimulation methods that allow a greater volume of reservoir to be accessed from a single surface location and decrease the environmental impact.
- Develop stimulation methods that require less water and other fluids to be injected into the subsurface.
- Develop stimulation methods that result in a lower volume of treatment fluids produced to the surface.
- Develop approaches for improved treatment, handling, re-use, and disposal of fluids produced and/or used in field operations.
- Extending the commercial life of a producing well through reduction of the initial drilling and completion costs, elimination of workovers and recompletions, as

well as reduction of production costs particularly those associated with water disposal and management.

Area of Interest 2: Water Management Associated with Coalbed Methane and Gas Shale Production

Scope: The solicitation will request proposals for development of tools, techniques and methods that may be applied to substantially decrease the environmental impact of produced and used water associated with coalbed methane and gas shale development. The concepts may include but will not be limited to the following areas:

- Develop methods for the treatment of produced water.
- Develop methods for sustainable beneficial use of produced water.
- Develop methods to control fines production.
- Develop techniques to minimize the volume of water produced to the surface.
- Develop water management methods to reduce drilling and completion costs
- Develop technologies for effective development of multiple thin bed coal seams.

Area of Interest 3: Tight Sands

Scope: The solicitation will request proposals for development of tools, techniques and methods to increase commercial production and ultimate recovery from established tight gas sand formations and, accelerate development of emerging and frontier tight gas plays. The concepts may include but will not be limited to the following areas:

- Characterization of geologic, geochemical, geophysical, and operational parameters that differentiate high performing wells
- Accurate delineation of the natural fracture system for guiding horizontal wells to intersect a large number of open fractures.
- Development of extra-extended single and multi-lateral drilling techniques.
- Development of steerable hydraulic fractures.
- Development of suitable low-cost fracturing fluids and proppants; e.g., non-damaging fluids and/or high strength low density proppants.
- Develop advanced drilling, completion and/or stimulation methods that allow a greater volume of reservoir to be accessed from a single surface location and decrease the environmental impact.
- Development of efficient and safe water management schemes.
- Extending the commercial life of a producing well through reduction of the initial drilling and completion costs, elimination of workovers and recompletions, as well as reduction of production costs particularly those associated with water disposal and management.

Establishment of Technical Advisory Committees

An important part of this process will involve input from a number of Technical Advisory Committees (TACs) to be established to help review and evaluate projects from those submitted in response to the solicitations. The TACs will also play a role in helping to refine subsequent solicitations.

These TACs will be formed, conduct their work and continue as long as needed. As the program changes and projects are completed, individual TACs will be closed as new ones are formed, based on program need. A number of potential TAC topics have been identified and individual experts have expressed their interest in serving on these committees. To a certain degree, the mix of proposals received will determine whether discipline-oriented groups, interdisciplinary problem-focused groups, or some combination will be required.

Funds Available and Anticipated Awards

It is anticipated that there will be $13.89 million available for funding the Unconventional Resources program element during each fiscal year beginning with 2007. Approximately 5 to 15 awards are anticipated to be awarded in the first solicitation of 2007 and those will be fully funded. If the quality of the proposals allows, then subsequent solicitations in 2008 will award double the number of projects and mortgage them.

The typical award is expected to have duration of one to three years, although shorter or longer awards may be considered if warranted by the nature of the proposed project.

E. Metrics

The overall goal of the Unconventional Resources program element is to increase the supply of domestic natural gas and other petroleum resources. The long term metrics for this program element and the Consortium in general are discussed in Section 2.5.

Short term metrics include the completion of annual milestones that show progress toward meeting the program element objectives. As a minimum, short term metrics from the end of FY 2007 through FY2008 shall include:

- Successfully issue and complete at least two solicitations.
- Establish technical advisory committees to review solicitations that reflect sufficient breadth and depth of industry experience to ensure a portfolio of high-quality projects.
- Select and award a minimum of 5 projects.
- Establish FY2009 R&D priorities based on results of 2007-08 solicitations and other inputs from the program advisory committees, and modeling the impacts of various R&D applications.

In addition, RPSEA will acquire and analyze the data necessary to accurately quantify base case and post technology application case assessments of technically recoverable and economically recoverable reserves, as discussed in Section 2.5. Determination of the Unconventional Resources program benefits will be fully coordinated with NETL's Office of Systems, Analysis and Planning.

F. Milestones

The first Solicitation will be conducted within two weeks after approval of the Annual Plan, and will remain open for 45 days (see Table 2.8). The review selection and award process will take no longer than two and one half months. Awards from the first solicitation will be fully funded while the second and any subsequent solicitations will more than likely create mortgages.

The following steps are represented on the timeline:

1. Submit Draft Annual Plan (completed)
2. Issue Solicitation 1 (Gas Shale, Water Management, Tight Sands focus)
3. Establish Technical Advisory Committees to review solicitations.
4. Administer selection and award of highest quality projects based on Solicitation 1 submissions
5. Issue Solicitation 2
6. Establish technical advisory committees to review solicitations.
7. Administer selection and award of highest quality projects based on Solicitation 2 submissions.
8. Develop and apply methodology for quantifying benefits as a result of the application of program-developed enabling technologies.
9. Establish FY2009 R&D priorities based on results of 2007-08 solicitations, inputs from the program advisory committees, and modeling of the impacts of various R&D applications.
10. Monitor progress of all awards and make any necessary adjustments to research plans.
11. Satisfactorily report all program deliverables to NETL.

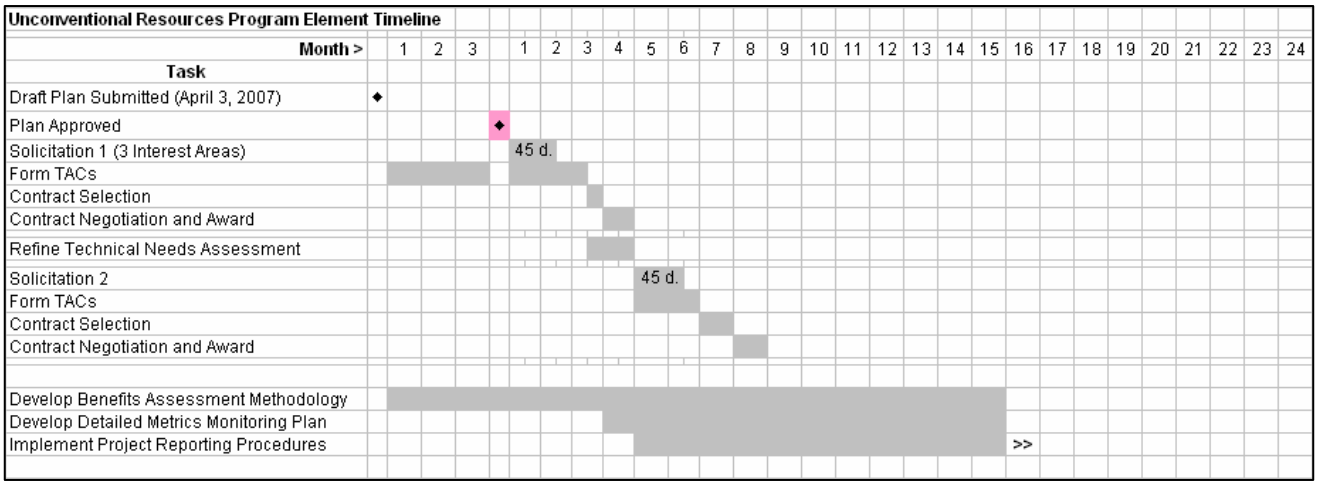


Table 2.8: Unconventional Resources Program Element Timeline

2.3 Small Producer Program Element

A. Mission

The mission of the Small Producer program element of the consortium-administered R&D program is to increase the supply from mature domestic natural gas and other petroleum resources through reducing the cost and increasing the efficiency of production of such resources, while improving safety and minimizing environmental impact, with a specific focus on the technology challenges of small producers.

"Small producer" is defined in EPACT as *an entity organized under the laws of the United States with production levels of less than 1,000 barrels per day of oil equivalent.*

B. Goal

The goal of the Small Producer program element is to ***add to the reserve base associated with mature fields operated by small producers*** by increasing the recovery factor, applying technology to make economically marginal resources economic and also to decrease the impact of development in environmentally sensitive areas. The target metric for this program element is to achieve a 10 to 1 return on R&D investment, in terms of the value of new reserves added in mature fields as a result of program-developed technologies. This target is to be achieved within the 2007-2017 timeframe.

C. Objectives

The objectives of the Small Producer program element are all near term in nature. It is anticipated that research contracts and deliverables will have a 1-3 year timeframe. This

program element is not focused on the development of new technology but rather the adaptation of technology for use by the small producer. The program does not preclude development of entirely new techniques or approaches, but any proposed will need to fit the near term timeframe for development. Strategically, the program will focus on overall field strategies and technologies as opposed to wellbore specific problem areas.

The Small Producer program element , perhaps more than any other, will require collaboration with existing technology transfer organizations, as well as a robust effort to communicate program results to as many small producers as possible through multiple vehicles.

The specific objectives of the Small Producer program element are:

Near term (2007-2010)
Objective 1: Apply technologies in new ways to enable improvements in water management and optimization of water use in mature fields.

Objective 2: Apply technologies in new ways to improve oil and gas recovery from mature fields, extending their economic life.

Objective 3: Apply technologies in new ways to reduce field operating costs.

Mid term (2007-2012)
Objective 4: Apply lessons from all near-term projects to new basins/areas and develop new technologies to address the problems of Objectives 1-3.

Long term (2007-2017)
Objective 5: Apply lessons from near- and mid-term projects, as well as new technologies from other program elements, to basins nationwide.

D. Implementation Plan

The Small Producer program element will be implemented by developing and administering solicitations for R&D projects in areas that address the objectives outlined above. The following section outlines the major steps in the implementation plan.

Small Producers Program Element Advisory Groups

The Small Producer program will receive guidance from a Small Producer Research Advisory Group (RAG) consisting of industry and academic representatives that are closely tied to the national small producer community (Appendix B). The RAG will focus on identifying, targeting, and prioritizing specific technology needs. This advisory group will also provide a key communications focal point for encouraging the formation of the requisite research consortia (see Sec. 999B (d)(7)(C) of the text of Section 999 provided in Appendix A for a description of this requirement). After projects are initiated, the RAG will follow each project's progress, plans and results, with particular attention to tech transfer. All projects will be reviewed by the RAG semi-annually.

While the RAG will be responsible for directing the Small Producer program, the Unconventional Onshore PAC will remain responsible for oversight of the entire onshore program, which includes the Small Producer program element as well as the Unconventional Resources program element. The RAG will interact with the Unconventional Onshore PAC through RPSEA Onshore VP and through its chairman who will hold a seat on the Unconventional Onshore PAC reserved for a representative of the Small Producer RAG.

While the Small Producer RAG will be the body primarily responsible for the management of the selection process for awards under the Small Producer program, the RAG will draw on the expertise of the specialized Unconventional Onshore TACs. These TACs will be available to provide in depth technical reviews on proposals that may fall outside the scope of the expertise present on the RAG.

Development of a Solicitation to Address Prioritized Technology Challenges

The Small Producer program element has been able to draw on the input from the exercises and workshops listed in the Unconventional Resources section of this plan (see Section 2.2 part C) , as well as specific events aimed at small producers conducted by New Mexico Tech and West Virginia University. The overarching theme expressed by small producer representatives at these events was the need for technology which allows them to maximize the value of the assets they currently hold, primarily in mature fields.

Accordingly, the solicitation under this program element will be aimed toward developing and proving the application of technologies that will increase the value of mature fields by reducing operating costs, decreasing the cost and environmental impact of additional development, and improving oil and gas recovery. Reducing risk is seen as key to reducing costs and improving margins. Improved field management, best practices, and lower cost tools (including software) are all within the scope of this effort.

In order to ensure that technologies developed under this program are applied to increase production in a timely fashion, each proposal will be required to outline a path and timeline to an initial application. A specific target field for an initial test of the proposed development must be identified, and ideally the field operator will be a partner in the proposal.

In compliance with EPACT, all awards resulting from this solicitation “shall be made to consortia consisting of small producers or organized primarily for the benefit of small producers.” For the purposes of the solicitation, a consortium shall consist of two or more entities participating in a proposal through prime contractor-subcontractor or other formalized relationship that ensures joint participation in the execution of the scope of work associated with an award. The participation in the consortium of the producer that operates the asset that is identified as the initial target for the proposed work will be highly encouraged.

The first solicitation will request proposals addressing the following technology challenges:

- Development of approaches and methods for water management, including produced water shutoff or minimization, treatment and disposal of produced water, fluid recovery, chemical treatments and minimizing water use for drilling and stimulation operations.
- Development of methods for improving oil and gas recovery and/or extending the economic life of reservoirs.
- Development of methods to reduce field operating costs, including reducing production related costs as well as costs associated with plugging and abandoning wells and well site remediation. Consideration will be given to those efforts directed at minimizing the environmental impact of future development activities.
- Development of cost-effective intelligent well monitoring and reservoir modeling methods that will provide operators with the information required for efficient field operations.
- Development of improved methods for well completions and recompletions, including methods of identifying bypassed pay behind pipe, deepening existing wells, and innovative methods for enhancing the volume of reservoir drained per well through fracturing, cost-effective multilaterals, in-fill drilling or other approaches.
- Implementation and documentation of field tests of emerging technology that will provide operators with the information required to make sound investment decisions regarding the application of that technology.
- Collection and organization of existing well and field data from multiple sources into a readily accessible and usable format that attracts additional investment.

Additional solicitations may be issued based on assessment of proposals received and available funding.

Funds Available and Anticipated Awards

It is anticipated that $3.21 million will be available for the Small Producer program element during fiscal year 2007. Approximately 4 to 12 awards are anticipated to be awarded in the first solicitation of 2007 and those will be fully funded.

The typical award is expected to have duration of one to three years, although shorter or longer awards may be considered if warranted by the nature of the proposed project.

E. Metrics

The Small Producer program element goal is to add to the reserve base associated with mature fields operated by small producers. The long term metrics for this program element and the Consortium in general are discussed in Section 2.5.

The short term metrics include the completion of annual milestones that show progress toward meeting the program element objectives. As a minimum, short term metrics from the end of FY 2007 through FY2008 shall include:

- Successful issuance of one solicitation
- Establishment of an advisory group that reflects sufficient breadth and depth of industry experience to ensure a portfolio of high-quality projects
- Selection and award of a minimum of 4 high quality projects.

In addition, RPSEA will acquire and analyze the data necessary to accurately quantify base case and post technology application case assessments of technically recoverable and economically recoverable reserves, as discussed in Section 2.5. Determination of the Small Producers program benefits will be fully coordinated with NETL's Office of Systems, Analysis and Planning.

F. Milestones

The solicitation will be conducted within two weeks after approval of the Annual Plan, and will remain open for 45 days (see Table 2.9). The review selection and award process will take no longer than two and one half months.

The following steps are represented on the timeline:

1. Submit Draft Plan (completed).
2. Establish advisory committee to review solicitations.
3. Successfully issue Solicitation 1.
4. Selection and award of high quality projects based on Solicitation 1 submissions
5. Develop and apply methodology for quantifying benefits as a result of the application of program-developed enabling technologies.
6. Establish FY2009 R&D priorities based on results of 2007-08 solicitations, inputs from the program advisory committees, and modeling of the impacts of various R&D applications.
7. Monitor progress of all awards and make any necessary adjustments to research plans.
8. Satisfactorily report all program deliverables to NETL.

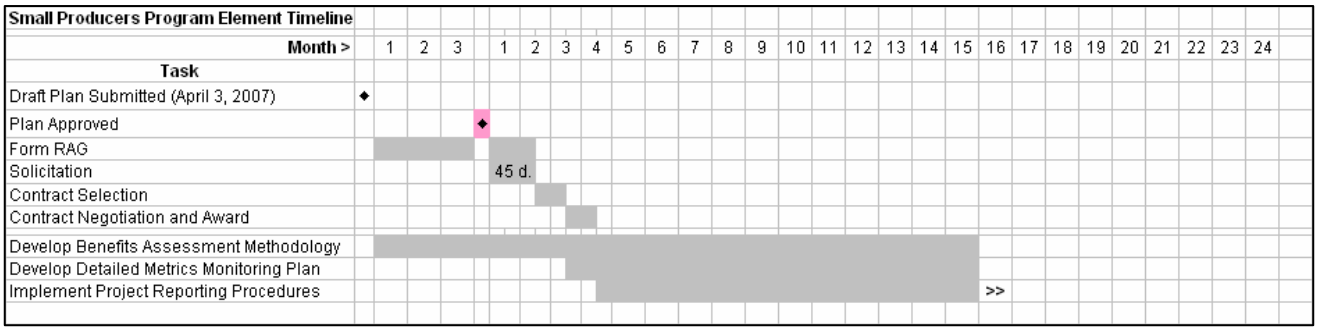


Table 2.9: Timeline for Small Producers Program Element Activity

2.4 Solicitation Process

A. Eligibility

In accordance with Section 999 of EPAct 2005, in order to receive an award, an entity must either be:

a) a United States-owned entity organized under the laws of the United States; or
b) an entity organized under the laws of the United States that has a parent entity organized under the laws of a country that affords-
    a. to United States-owned entities opportunities comparable to those afforded to any other entity, to participate in any cooperative research venture similar to those authorized under this subtitle;
    b. to United States-owned entities local investment opportunities comparable to those afforded to any other entity; and
    c. adequate and effective protection for the intellectual property rights of United States-owned entities.

RPSEA is not eligible to apply for an award under this program.

B. Organizational/Personal Conflict of Interest

The approved RPSEA Organizational Conflict of Interest Plan will govern all potential conflicts associated with the solicitation and award process.

RPSEA was required to submit an Organizational Conflict of Interest (OCI) Plan which, in accordance with Section 999B(c)(3) of EPAct 2005, addressed the procedures by which RPSEA will (1) ensure it's board members, officers, and employees in a decision-making capacity disclose to DOE any financial interests in or financial relationships with applicants for or recipients of awards under the program and (2) require board members, officers, or employees with disclosed financial relationships or interests to recuse themselves from any oversight of awards made under the program. RPSEA's OCI Plan was reviewed by DOE. After DOE's comments and questions were addressed, a final OCI Plan was approved.

In addition, the Contract between DOE and RPSEA includes the following OCI clauses: H.22 Organizational Conflict of Interest (NOV 2005); H.23 Organizational Conflict of Interest (OCI) Annual Disclosure; and H.24 Limitation of Future Contracting and Employment.

These Contract clauses and the approved RPSEA OCI Plan will govern potential conflicts associated with the solicitation and award process.

C. Solicitation Approval and Project Selection Process

The overall structure of the solicitation approval and project selection process is illustrated in Figure 2.4. Within the RPSEA project proposal review and selection process, the TACs will be responsible for providing technical reviews of proposals, while the PACs will be primarily responsible for the selection of proposals for award. NETL will be responsible for the final review and approval of recommended projects.

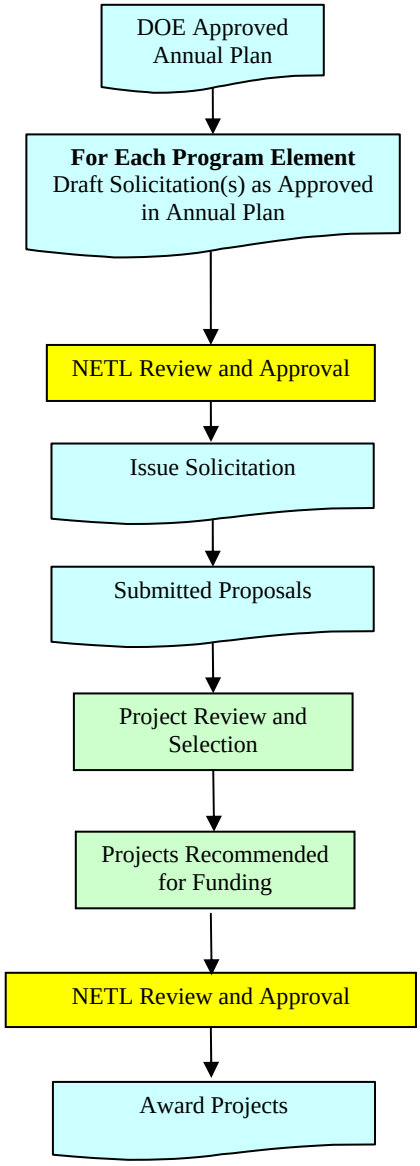


Figure 2.4: Project Solicitation Process

D. Selection Criteria

The following general criteria (which will be better defined in the individual solicitations) will be used to evaluate proposals submitted under the RPSEA program. Weighting factors will be determined prior to the issuance of each solicitation.

- Technical merit and applicable production or reserve impact
- Statement of Project Objectives

- Personnel qualifications, project management capabilities, facilities and equipment, and readiness
- Technology transfer approach
- Cost for the proposed work
- Cost share
- Environmental impact
- Health and Safety QA/QC
- Exceptions to contract terms and conditions

Weighting factors may vary depending on the specific technology theme and will be determined prior to the issuance of each solicitation.

A bidder may be required to meet with the review committee to present their proposal and to answer any outstanding questions.

The following additional criterion will be used to evaluate proposals submitted under the Small Producer program element: Approach to application of the results, involvement of small producers and the overall strength of the consortium.

E. Schedule and Timing

The schedule for the initial round of solicitations will be determined in consultation with NETL after the Annual Plan has been approved. It is anticipated that solicitations will be issued within two weeks of Plan approval. After issuance, solicitations will remain open for 45 days.

F. Proposal Specifications

The structure and required elements of proposals submitted in response to the solicitations, as well as the specific details regarding format and delivery, will be developed in consultation with DOE and will be provided in each solicitation.

G. Funding Estimates

It is anticipated that $14.96 million per year will be available for the UDW program element and $13.89 million per year for the Unconventional Resources program element. Approximately 5 to 20 awards are anticipated within each of these program elements during FY2008. The typical award is expected to have duration of one to three years, although shorter or longer awards may be considered if warranted by the nature of the proposed project.

It is anticipated that $3.21 million per year will be available for the Small Producer program element. Approximately 4 to 12 awards are anticipated during FY 2008. The

typical award is expected to have duration of two years, although shorter or longer awards may be considered if warranted by the nature of the proposed project.

H. Advertising of Solicitations

Advertising of each solicitation will be implemented in a manner that insures wide distribution to the specific audience targeted by each solicitation.

The vehicles used will include at a minimum:

- Publication on the NETL website, supported by DOE press releases
- Publication on the RPSEA website, supported by RPSEA press releases and newsletters
- Announcements distributed via e-mail to targeted lists (e.g., Small Producer solicitation to members of state producer organizations and IPAA).

Other vehicles that may be used include:

- Advertising in recognized industry publications (e.g., Oil and Gas Journal, Hart's E&P, Offshore, American Oil and Gas Reporter, etc.)
- Presentations at industry meetings by both RPSEA and NETL representatives, as appropriate given the timing of the solicitations.

I. Additional Requirements for Awards Specified in Section 999

The following items are specified in Section 999C as requirements for awards. This information must be included in the solicitations.

- ***Demonstration Projects –*** An application for an award for a demonstration project must describe with specificity the intended commercial use of the technology to be demonstrated.
- ***Flexibility in Locating Demonstration Projects –*** A demonstration project relating to an ultra-deepwater (≥1500 meters) technology or an ultra-deepwater architecture may be conducted in deepwater depths (>200 but <1500 meters).
- ***Intellectual Property Agreements –*** If an award is made to a consortium, the consortium must provide a signed contract agreed to by all members of the consortium describing the rights of each member to intellectual property used or developed under the award.
- ***Technology Transfer –*** 2.5 percent of the amount of each award must be designated for technology transfer and outreach activities.
- ***Information Sharing –*** All results of the research administered by the program consortium shall be made available to the public consistent with Department policy and practice on information sharing and intellectual property agreements.

2.5 Program Benefits Assessment and Performance Metrics

The primary overall goal of the Consortium-administered R&D program is to maximize the value to the Nation of domestic natural gas and oil by increasing the supply through cost reduction and efficiency improvement. Measuring the success of the program in meeting this goal will require monitoring and assessment on several levels:

1. ***Quantifying long-term program level benefits*** – Incremental additions to gas and oil supply, accelerated production rates, increased Federal or State royalty revenues, associated economic benefits (e.g., increased employment, lower energy prices, avoided costs), environmental benefits (e.g., reduced footprint, reduced emissions, etc.), "options" benefits (i.e., increase in technology options available to industry), and "knowledge" benefits (i.e., improved scientific understanding that can lead to future benefits). These benefits must result from the application of technologies developed by the Program.

2. ***Monitoring and reporting shorter-term program performance metrics*** – Milestones met, outreach achieved (e.g., papers delivered, workshops sponsored, awards received), technology transfer achieved (e.g., patents filed, company start-ups initiated, market share of commercialized technologies), level of industry interest developed (i.e., matching funds and in-kind contributions).

3. ***Monitoring and reporting program management performance and budget metrics*** – Budgeted versus actual cost metrics, project schedule adherence, invoice processing metrics, research project report quality and timeliness metrics, etc.

Level Three is directed primarily at measuring the performance of the Consortium in administering the program, Level Two at measuring the performance of the Consortium (through the research contractors) in achieving the objectives set forth in the Plan, and Level One at quantifying the overall success of the Program in achieving its primary goal. Each requires a monitoring and assessment plan and is discussed in the following sections.

A. Quantifying Long-Term Benefits

A long-term benefits assessment methodology will be developed that will result in a scientifically defensible and auditable determination of the economic benefits resulting from the R&D investments made. The long term benefits assessment will be coordinated with and drive future prioritization of technology focus areas in each of the three focus areas specified in EPAct Section 999. **This benefits assessment methodology and a plan for its implementation will be completed before the end of FY 2008 and its development will be fully coordinated with the SCNGO and OSAP at the NETL.** The methodology will be designed to meet the data and reporting requirements of NETL. Further, the methodology will be designed to produce assessments that can easily be

aligned with similar assessments produced for other government entities (e.g., the White House Office of Management and Budget, the U.S. Congress).

The methodology to be developed may include, but will not be limited to, the following elements:

1. A Benefits Matrix that correlates the *types* of benefits (e.g., economic, environmental, security) with the *category* of benefits (e.g., measured/estimated benefits actually realized, "options" benefits from increased industry flexibility, "knowledge" benefits from increased understanding). This matrix will be comprehensive and include any benefit that is to be measured or estimated.

2. The establishment of baseline values for key metrics (e.g. current values for technically and economically recoverable unconventional natural gas in particular basins, current deepwater production rates, etc.), as well as a methodology for determining changes in these key metrics over time. This may involve the independent collection and analysis of data by the Consortium where public data (e.g., MMS or EIA) is insufficient to provide the necessary level of detail.

3. A method for estimating the economic impacts that occur from an incremental increase in reserves or production rate and translating these into an economic benefit. For example: increased production from deepwater fields as a result of Consortium-developed technologies will reduce oil or gas imports and increase domestic supply; how does this translate into increased value for consumers? The application of a lower cost completion technology developed by the Program results in the drilling of additional gas wells; how does this translate into additional jobs and economic growth in the areas impacted?

4. A method for validating benefits associated with the application of specific Program-developed technologies. This may include "before-and-after" estimates from the operators involved with demonstrating a technology, market share estimates from service companies commercializing a technology, surveys of Consortium members and other operators applying a technology. The broad and deep relationships between the Consortium and the producing community will enable a larger number of detailed "testimonials" of the benefits of Program-developed technologies, where they have occurred.

5. A model for the expected long-term impact of new technology applications where commercialization has not advanced to the degree where market-based measurements can be easily made. A number of modeling approaches to this problem have been employed by EIA, DOE, and others. The Consortium will review these models and select an approach in consultation with NETL.

6. A plan for identifying and tracking increases in industry investment on development projects and spin-off technologies, within both service and producer market sectors, that directly result from (or indirectly evolve from) Program-

developed technologies. While this plan may be long-term in nature, there is a short-term need to build the networks for tracking these developments as soon as possible.

7. A plan for independent critical review of the benefits assessment methodology.

B. Monitoring Shorter-Term Performance Metrics

Quantifying the degree to which shorter-term metrics are met on a program basis will require that individual project metrics be established. The degree to which individual project objectives are met and the degree to which the roll-up of project objectives meet program objectives must be quantified. However, quantification of project-specific metrics will require the research program to be implemented and underway. Accordingly, the following steps will be followed with regard to quantifying short-term Program impact.

1. The R&D program needs to be initiated and the first round of project proposals received before establishing project level objectives and metrics.
2. During this time, the Consortium will review with DOE and select the most appropriate methodology for quantifying and tracking shorter-term program metrics.
3. After a methodology has been selected, a baseline will be established for all areas where short term metrics will be measured.
4. With the above information in hand, a projection of program short-term results based on an assumed R&D budget per year for a specified number of years will be modeled.
5. Based on the results of Step 4, more precise and quantifiable program objectives will be established (expected to be within a late 2007 timeframe, but dependent on the date of Plan approval).
6. The results will be reviewed with each of the Consortium advisor groups before finalization and submission to DOE for approval.
7. The process will be repeated on a yearly basis to quantify incremental project/program results and cumulative impacts.

While it is clear that achieving short-term goals is critical to long-term Program success, it is recognized that these are distinct metrics. The degrees to which project milestones are completed on time, papers are delivered, patents are filed, companies contribute cost-share funds and new technologies are determined to be successful and become commercialized are important indicators of the Program's short-term success or failure. However, the long term success of the program will ultimately be determined by the degree to which these short-term achievements are translated into the benefits outlined earlier.

C. Monitoring and Reporting Program Management Performance and Budget Metrics

In addition, as detailed within the RPSEA Management Plan, a monitoring process will be implemented for tracking budgeted versus actual financial information and other project schedule parameters. This monitoring process will include measurements of:

1. ***Obligated/uncosted funding in relation to total funds*** – The Consortium will establish a database to track obligated funding as well as uncosted amounts for the total program (including administration), as well as for each project.

2. ***Earned value assessment for each research project including individual project cost and schedule variation*** – Earned value management (EVM) metrics will measure the cost and schedule performance of each research project. These metrics will be based on three essential variables:

- **Budgeted Cost of Work Scheduled (BCWS)** which is extracted from the initial project plan. This variable lays down the baseline of planned expenditures at any given time.
- **Budgeted Cost of Work Performed (BCWP)** which is extracted from the initial plan and computed based on the reported work completed.
- **Actual Cost of Work Performed (ACWP)** which is extracted from a project's periodic reports and is the actual expenditure to complete a given task.

From these three variables, the Consortium administrator will determine the cost and schedule variance for each project.

Cost and schedule data will be collected from researchers on a schedule negotiated with the provider during the contract finalization process. The nature and characteristics of projects funded under the program will vary widely. The reporting frequency established for each project will consider these differences and vary as appropriate for individual projects, and will balance the need for information required to effectively monitor project execution against project schedules, milestones, and magnitude.

3. ***Project completion targets (within budget and project period)*** – The Consortium will utilize the three variables identified above to compute and report the estimated time at completion (ETAC) and estimated cost at completion (ECAC) for each project.

4. ***Adherence to project schedule (for solicitation and awards)*** – The Consortium will apply the same earned value techniques described above to the program level schedule for developing solicitations and making project awards. Earned value measurements will be made against the baseline schedule for the solicitation process.

In addition to the above, the Consortium will develop procedures to capture, monitor, and analyze data related to:

- Minimization of the amount of time from invoice to payment,
- Processing time for project change requests,
- Project report quality and adherence to set standards, and
- The number of small business, minority owned and other disadvantaged category program participants.

3. Complementary R&D Plan

This R&D plan describes research to be carried out by NETL that will be complementary to the R&D administered by the Consortium. This complementary program will have four principal areas:

- Drilling Under Extreme Conditions
- Environmental Impacts of Oil and Natural Gas Development
- Enhanced and Unconventional Oil Recovery
- Resource Assessment

In addition, there will be a fifth area of activity (see Section 4) where work will be done to identify and quantify the benefits that are expected to accrue as a result of the entire Section 999 Program, and to perform analyses in support of program planning.

Implementation of this plan relies upon existing NETL capabilities but also requires the building of new research competencies at the Morgantown, Pittsburgh and Albany facilities. These efforts will require active participation by the NETL-University Research Initiative, a partnership established between NETL and universities to further expand the research capabilities and available knowledge base with the DOE, as well as other industry and national lab partners. ORD will undergo peer reviews to generate evaluations of its R&D projects. The work described in sections 3.1 through 3.4 describes the initial complementary research program focus. Out-year R&D could be adjusted by comments taken from the peer review process.

3.1 Center for Drilling Under Extreme Conditions

The Center for Drilling Under Extreme Conditions (CDUEC) will improve the economic viability of drilling for and producing from domestic deep (greater than 15,000 ft TVD) and ultra-deep (greater than 25,000 ft TVD) oil and natural gas resources, benefiting the public by increasing the domestic supply of oil and gas. The research will be performed in unique, world-class facilities where researchers will conduct leading-edge fundamental research related to drilling under extreme conditions.

A. Motivation for Study of Drilling Under Extreme Conditions

The potential for domestic oil and gas production from deep and ultra-deep resources is considerable. There are an estimated 114-132 trillion cubic feet (TCF) of technically recoverable natural gas resource (onshore) and 55 TCF (offshore) trapped in reservoirs below 15,000 feet. Additionally, deep wells are often very large producers relative to their shallow counterparts. However, producing these resources often means drilling under extreme conditions, especially with respect to High Pressure and High Temperature (HPHT).

From an economic perspective, the drilling rate of penetration (ROP) is the single most important factor in determining the cost of drilling a well. Some reports applicable to deep drilling in the U.S. Gulf Coast state that: "over 50% of rig time is spent drilling the last 10% of the hole." In a cost benchmarking report prepared for DOE, the drilling/tripping cost category was found to average 50 percent of the total cost of deep wells. Improving the rate of penetration in the deepest segments of deep well drilling through technological advancements is a major motivation for this area.

Without technological advances, the cost of recovering deep resources will remain high. Thus, free market forces dictate that energy prices be sustained at high levels for the private sector to have incentive to develop these costly, deep resources. However, new technology and fundamental understanding of drilling under extreme conditions could reshape the economics of deep resource recovery.

B. Strategy

NETL's strategy is to make key contributions in the area of drilling under extreme high pressure and high temperature (HPHT) conditions in 5 major subject areas: 1) Drill bit-rock-fluid fundamentals, 2) numerical model development for rock mechanics systems, 3) development of novel drilling fluids, 4) development of sensors and electronics, and 5) materials development to provide new alloys having superior performance with respect to corrosion and erosion. Each of the five subject areas listed above are expanded upon here.

Drill bit-rock-fluid fundamentals – NETL is uniquely positioned to study HPHT drilling via physical simulation under carefully controlled laboratory conditions using the Ultra-deep single cutter Drilling Simulator (UDS). The UDS will be a one-of-a-kind research facility capable of recreating bottom-hole drilling environments of ultra-deep wells. The UDS capability includes operation at pressures up to 30,000 psi (2,068 bar) simultaneous with temperature up to 481 °F (250 °C). NETL's UDS is also unique in that it can operate with "real" drilling fluids, rather than simple fluids like water or air. This is an especially relevant distinction in that previous DOE-funded studies demonstrate that rate-of-penetration performance is several multiples higher for "clear base fluids" as compared to their corresponding drilling fluid. Visualization of physical experimentation is made possible by a sophisticated X-Ray video system that takes images of cutting at down-hole conditions, which includes cutter and rock immersed in an optically opaque drilling fluid.

NETL will carry out its strategy in the UDS initially by testing benchmark rock cores that match the physical properties of rock commonly encountered in basins of interest. Initial research will concentrate on benchmark rock cores of Crab Orchard sandstone, Carthage marble, and Mancos shale which provide analogs to rock encountered in the Arbuckle and Tuscaloosa deep gas plays. Shown below are specific examples of how NETL plans to execute the strategy described here:

1) PDC cutter studies on each rock benchmark. Parametric studies that vary drilling fluid weight (i.e. dissolved solids concentration) and type (examples

of various drilling fluids include water-base mud, oil-base mud, and cesium formate mud).

2) Studies that seek out optimal placement and characteristics of drilling fluid around the cutter-rock interface. This involves parametric studies that vary pressure, temperature, and classical dimensionless quantities known in the field of Fluid Mechanics (e.g. Reynolds Number, etc.).
3) Parametric studies that quantify the effects of weight-on-bit and contact angle during the rock cutting process for various systems.
4) Fundamental investigations that seek out physical evidence of drilling mechanisms and conclusions about the importance of each of these. Such drilling mechanisms may include any of the following:
    a) The hypothesized formation of a filter cake on the rock surface between cutter passes, and any effect it has on reducing friction, impeding fluid flow into pores, etc.
    b) The transfer of fluids between rock and wellbore during cutting, and any effect that this transfer has on ROP.
    c) The role of volume changing events in the rock phase and how/when this is advantageous or detrimental to rock cutting.
    d) The importance of particle size distribution with respect to dissolved solids in the drilling fluid. Emphasis will be placed on quantifying the possible advantages of nanofluid use in drilling fluids.

Numerical model development (rock mechanics) – Concurrent with physical simulation in the UDS, NETL is embarking upon numerical model development. These models seek to better explain and predict rock response to various drilling modes, including rock strain during cutting, formation of shear bands, and influence of fluids in rock pores. These activities ideally complement the physical simulation occurring in the UDS, as model validation becomes possible.

Novel drilling fluids – NETL's pioneering work in nanofluids opens pathways into novel drilling fluid development. Researchers will strive to make drilling fluid advances by establishing a new class of nanoparticle-based drilling fluid and/or by establishing nanoparticle additives to conventional fluids. These advances will potentially increase ROP of deep drilling systems. Concurrently with the Center for Environmental Impacts of Oil and Natural Gas Development (see Section 3.2), researchers will also investigate modified formulations of drilling muds to reduce the impact of drilling in environmentally sensitive areas.

High temperature sensors and electronics – NETL will also leverage its experience in high temperature sensor development to develop sensors and electronics capable of down-hole operation in HPHT wells. Specifically, NETL researchers will concentrate on Silicon Carbide technology that promises sustained operation at temperatures as high as 662 °F (350 °C). This area will leverage the 20+ years of NETL experience in advanced combustion where NETL researchers have developed and patented sensors and controls for operation at temperatures up to 2500 degrees °F (1371 °C).

Materials development – NETL will also use its expertise in materials and metallurgy to gage performance of materials exposed to extreme high-temperature, high-pressure, corrosive/erosive environments associated with deep and ultra-deep resources. NETL will apply its substantial expertise in material processing to deliver advanced alloys having superior performance in high temperature and sour applications.

C. Goals/Objectives

Near Term (by end FY 2008)

1) Make operational NETL's UDS, having capabilities described above in the strategy statement.
2) Conduct initial numerical simulations using NETL-developed Dynamic One-Dimensional Shear models to predict shear localization in rock formations as a result of various drilling activity and investigate material properties encountered in ultra-deep formations.
3) Characterize nanofluids created via laser ablation (a novel technique pioneered at NETL) and determine the potential of developing a new class of drilling fluids via Nanofluid technology.
4) Conduct initial research involving the development and testing of novel electronics and sensors for use in HPHT environments such as:
    a) SiC-based high-voltage and high current metal-oxide-semiconductor field-effect transistors (MOSFETs) and bipolar junction transistors (BJTs), which will be essential for motor drives and controls operating as high as 662 °F (350 °C)
    b) SiC-based devices for logic and analog circuits to process signals from high-temperature sensors (described below) and to subsequently communicate measured reading with the surface
    c) High-temperature instruments, such as accelerometers, magnetometers and gamma ray detectors. Research in the near term will concentrate on wide band gap semiconductors, interfaced with sensor circuits containing SiC devices, and
    d) Ohmic and Schottky contacts that do not degrade at elevated temperatures.
5) Identify performance shortfalls in currently-available tubular materials in sour environments at moderately high temperatures and pressures. This assessment will include the High Interstitially Strengthened Steel (HISS) alloys currently being developed at NETL. Specifically, the assessment will include identification of performance gaps with respect to: 1) stress-corrosion of tubular materials, and 2) wear-corrosion of tubular materials. If the HISS alloy performs well, then this assessment will help provide confirmation of the potential of HISS alloys for deep well drilling applications and the benchmark testing against commercially available products will provide a quantifiable measure of value.

Intermediate Term (by end FY 2012)

1) Publish the results of 8 parametric studies conducted in the UDS that identify possible opportunities for improvements in Rate of Penetration applicable to deep and ultra deep oil and gas drilling.

2) Continue research in high temperature electronics as described in the near term section. The following milestones are expected during the intermediate term:
   a) Test SiC-MOSFET and SiC-BJT for high-current operations at 350 °C.\
   b) Develop and test SiC electronics interface and aluminum nitride (AlN) accelerometer for deep submergence operation at 350 °C.
   c) Develop and test SiC electronics for wireless communication at 350 °C.
3) With an effort commensurate with the conclusions reached in the near term materials performance assessment, develop proof-of-concepts for new materials that can fill identified HPHT performance gaps.
4) Work with industry to identify persisting technology gaps, leading to additional goals for the 2012 – 2017 time frame.

Long Term (through fiscal year 2017)

1) NETL will work with industry to accelerate the deployment of technologies developed during the Intermediate Term.
2) With near and intermediate term conclusions from Resource Assessment activities (see Section 3.4) known, identify new plays of interest, with respect to large potential of ultra-deep resource in place. NETL will capitalize on this opportunity by using the UDS to study new but appropriate benchmark rocks via a research regimen similar to the UDS work detailed under the Intermediate Term.

D. Anticipated Results

Through use of NETL's unique Ultra-deep single cutter Drilling Simulator, numerous research activities will be reported in open scientific literature for use in advancing technology by industry and academic stakeholders. Disseminating information in this manner, and possibly collaborating with private sector entities via cooperative research and development agreements (CRADAs) will result in making superior commercial products available for drilling under extreme conditions.

By performing validation studies of existing and new numerical models, numerical simulation techniques will be advanced to the stage of reliably predicting drilling mechanisms under extreme conditions such that commercial advanced drilling products can easily be developed in the private sector.

Research findings will enable commercial drilling products exhibiting Rate of Penetration (ROP) 10 times better than what is currently commercial when drilling very hard rock in ultra deep HPHT application. This will be accomplished by coupling knowledge gained from study of drilling processes, rock mechanics, drilling fluids, and simulation techniques. This may also involve a combination of disseminating information via publicly available literature and partnering with commercial entities via CRADAs or similar agreements.

Instruments and electronics that can operate in HPHT wells will be made available to the industry. This will be accomplished through publication of studies on novel electronics

and sensor and through partnering with commercial entities via CRADAs or similar agreements.

Advanced materials will be made available to industry for drilling and/or operating wells in HPHT and/or sour reservoirs. These advanced materials will have superior performance with respect to corrosion resistance and usable lifetime.

E. Anticipated Impact

As a result of NETL's work under EPACT Section 999, it is anticipated that:

- The commercially realized drilling rate of penetration (ROP) for ultra-deep hard rock will improve by a factor of 10 from current levels encountered in the deepest portions of HPHT wells. Specific to this most economically challenging portion of HPHT drilling, this translates to an ROP increase from a typical 3 ft/hr to about 30 ft/hr, having a transformational impact on the economics of deep drilling. This will allow for the economical production of deep and ultra-deep resources that were previously uneconomical.
- Down-hole electronics and instruments will become a commercial reality for high temperature / high pressure wells.
- Superior metallurgy will be available for tubulars in HPHT and sour environments. This will have positive impacts with respect to economics of deep resource recovery and potential environmental threats resulting from early component failures.

3.2 Center for Environmental Impacts of Oil and Gas Development

The Center for Environmental Impacts (CEI) will provide unbiased scientific information and analysis on the environmental impacts of oil and natural gas development, and develop and evaluate new technology or strategies to cost effectively deal with such problems. It will quantify the benefits of new technologies by comparing them to existing practices.

A. Motivation for Research on the Environmental Impacts of Oil and Natural Gas Development

Environmental concerns are among the most pressing issues limiting U.S. oil and natural gas production, causing significant delays and financial burdens to large and small operators. Environmental protection concerns also limit access to extensive portions of the domestic oil and gas resources. Responsible management of the nation's valuable oil and gas resources requires that these environmental concerns be grounded in sound and objective science and, where feasible, mitigated through advanced technology solutions. Environmental studies conducted or paid for by either industry or environmental groups can be viewed as biased; NETL is uniquely positioned to provide objective, credible science and technology solutions that both protect the environment and reduce costs for industry. Some of the most important issues are highlighted here.

- Produced water management is the single biggest cost for on-shore domestic producers. While much of this water is re-injected for pressure maintenance, a significant volume must be disposed of through on-site injection, treated and discharged, or transported to a commercial treatment facility.
- Disposal of produced water from coal bed natural gas (CBNG) is limiting a critical supply of natural gas needed to meet U.S. demand. Produced water issues have essentially stopped CBNG development in Montana and have crippled the pace of development in Wyoming. CBNG produced water concerns differ from other produced waters in that the water is potable or near potable when produced, but mineral interactions from surface disposal can damage soils or cause ground water contamination when the water dissolves additional salt from the soil.
- More than 138 tcf of technically recoverable natural gas underlies on-shore Federal lands. Approximately one third of this resource is effectively off-limits because of environmental stipulations. While these stipulations are intended to protect the environment, many were developed without adequate scientific research.
- Air quality is another issue limiting oil and gas development. In order to comply with Clean Air Act requirements, State and Federal regulators have either restricted development or have imposed costly emission control requirements. Estimates of air quality impacts are generally based on models that treat all oil and gas development in a state as a single point source. This gives a very different impact than would result from modeling the many small, widely dispersed sources that actually exist.
- Access to CO_2 for enhanced oil recovery (EOR) is limited by economics and by pipeline location. At the same time, greenhouse gas emissions (both CO_2 and CH_4) from oil and gas production activities are a developing concern. Recent research indicates that it could be possible to conduct EOR using CO_2 captured directly from the atmosphere if the capture technology could be made more economical.
- Oil shale resources in the Green River Basin exceed 2 trillion bbls, the single largest liquid fuels resource in the world. With oil prices high, technologies exist to make economic recovery of this resource a reality. However, because these resources are mostly on Federal lands, many environmental concerns will have to be addressed before large scale production will be allowed to proceed. Chief among these are the issues of water availability and quality for maintaining a large-scale (>1 million bbls/day) oil shale industry.

B. Strategy

DOE/NETL's strategy is to remove environmental barriers to oil and gas production by 1) developing environmentally benign technologies for managing produced water, 2) anticipating environmental barriers to future sources of oil (oil shale) and proactively identifying/developing extraction methods that minimize water use and environmental impact, 3) developing more realistic models of air emissions from E&P activities that are based on actual measurements from widely dispersed sources, and 4) implementing

research to better understand ecosystems impacted by E&P activities and their vulnerabilities.

Managing produced water – Industry, regulators, and environmental interest groups concur that issues with the treatment, disposal, or beneficial use of produced water are currently the primary barriers to oil and gas production. The Center for Environmental Impacts of Oil and Natural Gas Development (CEI) has prioritized the following research activities to mitigate produced water issues. Specifically, the CEI will:

- Evaluate subsurface drip irrigation (SDI) as a beneficial use for produced water. The study will determine the long-term effect of SDI on crop yield, soil permeability, shallow hydrology, and salt mobilization.

- Test helicopter electromagnetic induction surveys as a rapid means to determine the soil salinity of large areas. The quality of produced water that can be discharged to ephemeral or intermittent streams is based on estimates of soil salinity according to Wyoming's Agricultural Use Protection Policy (Chapter 1, Section 20). A faster, less expensive method for determining soil salinity would expedite discharges of produced water.

- Conduct channel morphology studies to determine the maximum rate that produced water can be discharged to a drainage system before significant erosion or flooding occurs. Currently, produced water discharge limits are conservative; better knowledge of channel flow capacity may permit greater amounts of produced water to be discharged safely.

- Initiate studies to determine the fate of salt deposits and high TDS aquifers when produced water is discharged into overlying dry stream systems or infiltration pits. The quality of infiltrating produced water is expected to be degraded by contact with salt deposits; infiltrating produced water probably will dilute and laterally displace high-TDS water in shallow aquifers. Previous NETL work has shown that salt deposits and shallow, high-TDS aquifers can be mapped using helicopter electromagnetic induction surveys. Such areas can be avoided if this study shows that the infiltration of produced waters has a deleterious effect on underlying Class 1 aquifers or nearby surface streams.

- Identify and exploit opportunities to use passive treatment technologies as pretreatments for the membrane treatment of produced water or as a low-cost means of removing BTEX compounds in legacy oil fields. Only limited options exist for the treatment of high sodium produced waters and there is little likelihood that significantly better technologies will be developed. Further, the two most effective current treatments (reverse osmosis or electrodialysis) require pretreatment to prevent irreversible fouling of expensive membranes. Low-cost, passive pretreatment technologies will be developed that will increase the service life of membranes and, thereby, lower the overall cost of produced water treatment.

- Identify geologic formations in oil and gas producing areas that are suitable for the injection of concentrated brines from the reverse osmosis or electrodialysis treatment of produced water.

Identifying/developing oil shale extraction methods that minimize water use and environmental impact – The Center for Environmental Impacts for Oil and Gas Development will conduct research to determine the environmental impact of proposed oil shale extraction technologies. Because oil shale deposits are located in arid-semiarid regions where water resources are limited, water use and the potential contamination of water resources by oil shale extraction will be of paramount concern. CEI will estimate water use for each proposed oil shale extraction technology and evaluate methods to prevent contamination of regional surface and groundwater supplies. Specific to this subset of NETL's strategy, CEI will:

- Work with oil shale developers, other federal agencies, and the states to estimate the water consumption of present and emerging technologies and identify potential sources of air and water pollutants.

- Evaluate the efficacy of applying commercially available pollution control technology developed for other industries to oil shale operations. Currently, no installation and testing of this equipment on full-scale oil shale plants have taken place. Today's commercial water treatment technologies cannot be simply applied at full scale at an oil shale plant, but first must be successfully demonstrated at a smaller scale to evaluate the technology and minimize investment risk.

- Develop environmental strategies that protect atmospheric and groundwater resources at in-situ retort sites. Although surface and in-situ retort pilots of the 1970-80's complied with existing environmental law, today's environmental regulations are more restrictive. Greater gas and water treatment capabilities will be required today and in the future. Further, water flushing of underground residual spent shale retorts was used previously to reduce toxic and other contaminants to safe levels. However, more that 10 years were required to flush and cool the spent retort and surrounding rock. The effectiveness of water flushing for preventing groundwater contamination at in-situ oil shale retorts will be re-evaluated and alternative strategies identified.

Developing models of air emissions from E&P activities – The Center for Environmental Impacts for Oil and Gas Development will develop more relevant models for air emissions from E&P activities than those currently used by EPA and state air quality regulators. Air emissions will be modeled as discrete sources and will be validated by monitoring of actual sources from conventional oil and gas operations, coalbed natural gas operations, and enhanced oil recovery operations. Emission monitoring will be conducted at different altitudes using sensors and sample collectors on unmanned helicopters or attached to tether lines from balloons. These data will be used to construct 3-D models of contaminant plumes downwind from E&P activities and identify areas of potential impact.

Improve understanding of the impact of E&P activities on sensitive ecosystems -- The U.S. Forest Service has requested that DOE/NETL conduct surveys to determine the effect that access roads for E&P activities may have on nearby ecosystems. Although the Forest Service request was specific to E&P road construction in eastern forests, ecological impact surveys will be expanded to cover the construction of well pads, pipelines, and electrical utilities in all areas where E&P activities are occurring. These studies will also include the impact that drilling operations may have on raptors, sage grouse, and other wildlife species.

The CEI will work with existing organizations and regulatory agencies to ensure that the results of this work are widely know and implemented in a way that both improves the environment and increases access to resources. Geospatial data from the CEI will be continuously updated and provided to the public via interactive web sites.

C. Goals and Objectives

Near Term (by end FY 2008)

1. Assess and prioritize the barriers identified in previous NETL and industry work to determine the areas that offer the most likely chance for increased production in the near term. This will include, among others, areas such as sub-surface irrigation of CBNG produced water and expediting produced water discharge permits using provisions of Wyoming's Agricultural Use Protection Policy (Section 20).
2. Initiate a coordinated interdisciplinary and multi-organizational study to scientifically assess produced water, its environmental impact, various treatment and disposal options, and the potential for beneficial use. Experimental wetland treatment systems will be assessed, including field-based evaluation of water quality changes over time.
3. Initiate research on the mobilization of salts within a drainage system as CBNG produced water is transported down-gradient. Determine the subsurface connectivity between shallow groundwater aquifers and the surface water system. Evaluate remote sensing technologies such as airborne electromagnetic induction surveys for the extensive mapping of soil salinity of large areas.
4. Investigate the application of light detection and ranging (LIDAR) technology in measuring channel geometry for estimating the amount of water that can be discharged into ephemeral drainages before significant erosion or flooding problems occur.
5. Identify information gaps necessary to assess the impact of air emissions from E&P activities and conduct assessment studies needed to develop models of the impacts of E&P on local and regional ambient air quality. If required, conduct targeted on-site measurements of emissions from E&P activities that may impact the environment.

6. Initiate a coordinated multidisciplinary study of the ecological impact of contemporary and historical O&G activities (well pads, road construction) in a designated watershed on federal land within the Appalachian basin, in cooperation with the U.S. Forest Service and U.S. Bureau of Land Management. Also, reassess available data on the effects of oil and gas activity on nesting raptors, and on sage grouse habitat.
7. Initiate a collaborative Federal and industrial research effort to provide reasonable estimates for water consumption associated with producing oil from shale at various rates and various extraction technologies, and to address how this will impact present and future water demands within the region.
8. Establish procedures for data management and the dissemination of spatial information using modern geographic information system (GIS) technology that meet standards established by the Federal Geographic Data Committee. The GIS spatial database will incorporate collected and available data and demonstrate its utility in the management of contemporary O&G activities.

Intermediate Term (by end of FY 2012)

1. Publish an evaluation of produced water management strategies that addresses cost versus effectiveness.
2. Publish new models for airborne contaminant plumes from oil and gas development activities, using field data to calibrate the models.
3. Complete analysis of airborne surveys over CBNG produced water management areas in the Powder River basin and data interpretations. Incorporate airborne interpretations into GIS models to identify optimal produced water disposal locations. Make this information immediately available to regulators and industry to expedite the issuance of produced water discharge permits.
4. Suggest surveillance plans to protect communities near EOR or gas storage fields based on measuring, monitoring, and verification (MMV) technologies developed as part of NETL's geological CO_2 sequestration research, and develop recommendations for mitigating gas migration.
5. Refine an upper and lower limit to the potential quantity and quality of water required from available regional water sources (including local rivers, produced waters, mine discharges, and wastewater) to support an oil shale industry at various levels of production, incorporating research being conducted by the Center for Enhanced and Unconventional Oil Recovery.
6. Complete studies in a research watershed on Federal land and fully assess the utility of the spatial database and modeling to predict and minimize the environmental impact of O&G activities. Identify and report innovative technologies/practices for study and implementation to alleviate identified environmental impacts. Initiate parallel watershed assessments in multiple environments representative of major O&G development regions of the U.S.

Long Term (through FY 2017)

1. Propose a data collection, processing, and model construction methodology for produced water disposal management as part of technology transfer. All computational programs developed will be given to industry for their own use.

2. Complete four major watershed assessments and fully transfer data to industry and public.
3. Demonstrate and document the minimization of ecosystem and wildlife habitat degradation associated with O&G activities due to the implementation of NETL-developed modeling programs and research.
4. Complete technology transfer of all CEI research.

D. Anticipated Results

By building on its excellent working relationship with industry and other government agencies and its growing expertise in this technical area, ORD's CEI will:

- Publish evaluation of subsurface drip irrigation systems as a water management alternative for produced water disposal in the Powder River Basin. Positive results from this study will allow Wyoming DEQ to issue produced water discharge permits that are currently on hold.
- Publish comparison of airborne soil conductivity mapping to conventional ground-based soil conductivity surveys. Time and cost efficient salinity mapping using helicopter electromagnetic induction will expedite permits to discharge produced water into intermittent or ephemeral streams.
- Publish results of study of innovative treatment options and the relative cost effectiveness of the technologies available to treat brine and oil contaminated waters.
- Interpretations from helicopter electromagnetic induction and surveys will be incorporated into GIS models that can be used to identify optimal produced water disposal locations. Results of airborne surveys will be provided to the public as GIS-based mapping products via GIS server technology, and will include decision support models that will enable industry and states to better manage CBNG produced water.
- Determine if and to what extent oil shale development might be limited based on water availability and other factors, and refine this as additional technology is developed by the Center for Enhanced and Unconventional Oil Recovery to enhance kerogen production and reduce water requirements.
- Publish results of source – receptor modeling studies of the airborne impacts of small scale oil and gas development. Determine the nature, scope and variability of the impacts for different E & P activities, geographic sites, and meteorological conditions. Determine common characteristics that can be addressed in a consistent manner for multiple locations, and those characteristics that are site and operation specific, requiring a customized approach.

E. Anticipated Impact

Through the interdisciplinary and multi-organizational study of produced waters, the economic burden on small operators for the treatment and disposal of these waters should

be significantly reduced, consequently stimulating oil and gas production, while environmental protection will improve. The most promising technologies for safe, effective, economical treatment and beneficial use of produced waters will be identified.

The impact of small–scale E&P activities on local and regional air quality will be established through air quality studies and source–receptor modeling to reduce the regulatory compliance economic burden on operators. The CEI will establish what air pollution controls, if any, are required by small producers to comply with requirements of the air quality State Implementation Plans.

Water and other environmental challenges facing oil shale development will be collaboratively and proactively assessed and dealt with so that industry will have viable technical options available to address potential environmental problems prior to development. This work will allow the environmental framework that will allow oil shale development to proceed in a manner that protects the environment.

GIS will be used to disseminate information via WEB portals for public and private applications; decision support models will be developed to support data analysis and the development of risk assessment tools.

3.3 Center for Enhanced and Unconventional Oil Recovery

The Center for Enhanced and Unconventional Oil Recovery (CEUOR) will focus on the mission of developing advanced technologies that will move the status of known but unrecoverable oil resources to technologically and economically producible resources.

A. Motivation for Research on Enhanced and Unconventional Oil Recovery

Conventional primary and secondary recovery operations often leave two thirds of the oil in the reservoir. In the U.S., an estimated 400 billion barrels of the discovered oil resource remains unrecovered. Historically, U.S. industry tertiary or enhanced recovery practice has been to inject steam, carbon dioxide (CO_2), or surfactants into reservoirs to move residual oil to production wells. Often these “floods” have been undertaken without detailed knowledge of the localized geology, which can often be very complex, or without economical means to monitor or map the fluid movement continuously over time. The missing information includes data related to depositional environment, fluid saturations, and the degree to which the pockets of residual oil or gas remaining in the reservoir are connected to one another.

U.S. EOR practices are widely applied but steam and CO_2 miscible flooding account for most of the incremental production (80%) and technological advances in these processes could have widespread impact. For example, CO_2 miscible EOR recovers only 10-15 % of the remaining oil due to limited reservoir contact by the injected CO_2. With the advent of carbon capture technology, millions of tons of CO_2 may be available in parts of the country where CO_2-EOR has been non-existent due to the regional unavailability of

carbon dioxide. Improvements in CO_2 miscible EOR technology to reduce the cost or improve the recovery efficiency could dramatically revitalize many of these depleted oil fields.

Unconventional oil resources that exist in oil shale in the U.S. contain an estimated 1.2 trillion barrels of oil equivalent in Colorado, Utah and Wyoming. The best existing technologies for producing oil shale have yet to be tested beyond the pilot scale. The lessons learned and the technologies developed from these past efforts remain available and provide the technical basis needed to advance oil shale commercialization efforts. The resource has been characterized in great detail over the last twenty five years, but current research needs to be concentrated on a number of key barriers; reducing the cost and improving the efficiency of oil shale recovery, reducing water requirements, and mitigating potential environmental damage due to development.

B. Strategy

NETL's strategy is to make contributions to the development of domestic oil reserves by addressing seven petroleum industry needs identified in past workshops: 1) creation of a high quality digital database of reservoir characterization data that can be utilized in the development of EOR, oil shale and tar sand resources; 2) completion of basin characterization models that will evaluate the entire stratigraphic column as a resource for both production of oil and water and treat these as potential products for future use, 3) development of better model algorithms, 4) development of new additives and catalysts that can aid in the recovery of shale oil and tar sands, with an emphasis on reducing the energy required for in-situ processes, 5) development of new uses for the spent shale byproduct of surface oil shale processing, 6) development of more efficient, cost effective, high resolution, disposable downhole sensors that can transmit data to the surface regarding the dynamic reservoir environment, and 7) development of materials and techniques that will enable economic CO_2 and thermal flooding to be applied in a larger number of mature fields.

Data Management – NETL will create a high quality database of reservoir and reserve characterization information for application to basin modeling. There is an industry identified requirement to provide more detailed information to the petroleum industry on the reservoir characteristics of oil in place (OIP) and oil processing methods for shale and tar sands to make them an economic energy resource for the future. The majority of the historic project reports contain data that can be used to develop plans for enhanced production methodology and create new processing technology to reduce requirements for water and energy requirements to produce them.

Basin and Reservoir Models – Develop basin characterization models that will evaluate the entire stratigraphic column for production of both oil and water and treat both as potential resources. The management of fluids over an entire geologic column will be considered and products from the processing may be disposed of in the same formations. The results will lead to more economic production, reduction in waste disposal and optimal utilization of water during development.

Model Algorithms – The petroleum industry will require more powerful computer capabilities to process the large amounts of data that can be collected with the development of higher resolution instrumentation. The prediction is that new databases and analytical software will exceed the industry's current maximum teraflop processing capabilities. New algorithms to reduce the data through statistical processing may be one method of reducing the load.

Additives and Catalysts for Oil Shale Production – Large volumes of water and a large amount of energy will be required for the extraction of oil from the shale formations. Chemical additives and catalysts will be studied in order to provide lower cost and lower temperature alternatives to current high water requirements and energy for extracting the oil. It is anticipated that the results will also lower the production of carbon dioxide, in the case of oil shale, and improve total recovery of the high temperature carbon trapped in the shale.

Spent Shale By-Product Testing – NETL will design experiments to test the products created during extraction and processing and create new uses that will reduce the amount of spent shale and sand that would otherwise result in unwanted disposal costs. Overall, the reduction in material handling costs will allow for a cleaner, more cost effective method of producing oil shale.

Sensor Development – NETL will pursue technology developments related to acoustic and seismic sensors and will develop a basic nanotechnology program to create sensors capable of providing real-time information on conditions within the reservoir that can help operators adjust their EOR strategies to improve resource recovery. NETL will also evaluate the current state of technologies to improve well bore sensors for both static and dynamic reservoir conditions.

Enabling Technologies for CO_2 and Thermal EOR – NETL will pursue technology developments to enable wider application of CO_2 and thermal EOR. This will include assessments of the impact of using low-quality CO_2 captured from emission streams on the efficiency of oil recovery, developing low cost alternative materials that will enable pipeline transporation of H_2S-contaminated CO_2, development of conformance control materials for improving the sweep of CO_2 floods in heterogeneous reservoirs, and potentially, developing ways to reduce the Minimum Miscibility Pressure of CO_2 such that miscible flooding can be achieved in shallow reservoirs. NETL will also take a science-based approach toward new and novel thermal practices that will allow adaptation of current heavy oil recovery technology to deeper and more geologically complex reservoirs.

C. Goals and Objectives

Near Term (by end FY 2008)

1) Create reservoir characterization data archives from historic NETL EOR, tar sand and oil shale project results. The data will be improved with continued analyses of samples from ongoing projects with industry and partnerships with other government

agencies. Laboratory analyses of fluids and formation interactions with carbon dioxide will provide improved input to the reservoir modeling effort and aid in the design of methods unique to each reservoir depositional environment.

2) Assess the current economic viability of various technology scenarios for oil shale development including surface mining, deep mining, in-situ, and surface retorts. Use this analysis, along with concurrent analysis of existing and new approaches to oil shale development, to identify technology gaps in unconventional shale and tar sand production. Identify potential solutions to the problems of high water requirements and waste products from the processing scheme.

Intermediate Term (by end of 2012)

1) Through experiments aimed at understanding the mobility of CO_2 within rocks, develop new techniques for improving the mobility control of CO_2 floods. The long-term goal will be to improve recoveries of oil from CO_2-EOR by 100-200% over the next two decades.
2) Assess the impact of using low-quality CO_2 on the efficiency of oil recovery.
3) Complete an assessment of alternatives for achieving miscibility in CO_2 floods in shallow reservoirs.
4) Test oil shale processing by-products and develop a slate of potential commercial uses. Assess the economic impact of these uses on oil shale development economics and outline barriers to commercial acceptance.
5) Investigate new and novel thermal practices that will allow adaptation of current heavy oil recovery technology to deeper and more geologically complex reservoirs.

Long Term (through fiscal year 2017)

1) Support and accelerate the development of nano-sensors capable of providing real-time information of conditions within the reservoir at a low cost.
2) Develop and test low cost alternative pipeline materials to enable the use of H_2S-contaminated CO_2 in EOR projects on a cost-effective basis.
3) Develop new and better algorithims to reduce that can significantly reduce the processing requirements for reservoir simulators.
4) Develop basin characterization models that will evaluate the entire stratigraphic column for production of both oil and water and treat both as potential resources.
5) Develop and test new catalyst that will reduce the temperature of or increase the reaction rate for in-situ pyrolysis of oil shale.

D. Anticipated Results

The Center for Enhanced and Unconventional Oil Recovery will produce detailed reports on the research topics listed above and work to disseminate the results to those sectors of the industry that can best utilize them. The Center will collaborate with outreach organizations to enhance the utilization and effectiveness of the technologies developed.

Key results anticipated from this effort include:

- The assessment and identification of the critical technology gaps that hinder the development of an economically and environmentally sustainable oil shale industry.
- Products that provide industry with valuable data and insights that can help to lower the cost and improve the efficiency of EOR and unconventional oil recovery.
- Production and delivery of timely reports that respond to the needs of the domestic industrial sectors involved in EOR and unconventional oil production.

E. Anticipated Impact

The products to be developed by CEUOR will enhance the domestic oil industry's ability to produce remaining U.S. conventional oil resources and yet-to-be-developed unconventional oil resources in a cost effective and environmentally benign manner. These products will accelerate and broaden the application of EOR using captured CO_2, an outcome that will both add to domestic oil production and help to create a market mechanism for capturing and sequestering CO_2. Advances in this area alone could result in the production of 100 billion barrels of domestic oil.

In addition, unconventional oil from oil shale and tar sands have between 700 and 1200 billion barrels of potential that await the development of technologies to overcome shale oil extraction and processing and water requirement issues. CEUOR products will enhance the ability of U.S. companies to cost-effectively translate this potential into reserves in an environmentally acceptable manner.

3.4 Center for Resource Assessment

The Center for Resource Assessment will provide characterizations of emerging, underutilized, or poorly understood oil and natural gas resource elements, and use these assessments to investigate the potential impacts of technology advances on these resources. It will largely focus on natural gas resources but has the potential for coordination with Section 3.3 on oil related assessment needs. Products from the Center will serve both as inputs to analyses of the potential benefit of various alternative technology pathways, and as contributions to industry and the larger research community's need for objective, detailed descriptions of resource characteristics and volumes.

A. Motivation for Resource and Technology Assessments

The domestic gas resource base is extremely large and many of these resources have never been fully characterized by either the public or private sectors. Significant resources of unconventional gas locked up in (mainly) tight gas sands, shales, and coalbed methane exist throughout the Rocky Mountains, Texas, Oklahoma and the Appalachian basin. Independent operators who predominate in exploration and development in the lower 48 states drill 90 percent of the wells and produce 82 percent of the natural gas and 68 percent of the oil. These operators do not have the staff or budget

to conduct detailed assessments of the large resource base to prioritize E&P activities. Past DOE-funded assessments conducted by the United States Geological Survey made industry aware of the full potential of unconventional resources and spurred E&P activities in these overlooked plays.

To date, thousands of copies of CDs from previously completed resource assessments conducted by NETL have been ordered and distributed to researchers and industry. The reports, interpretations, and digital datasets in these assessments have contributed to technology advances and increased industry exploration/development activities domestically.

Most resource assessments are designed to quantify either 1) the bulk gas-in-place with no regard for recoverability, or 2) the recoverable resource present under an assumed set of conditions. Assessments conducted by the Center for Resource Assessment will differ fundamentally from those conducted by other organizations. NETLs work will produce datasets from which recoverable resources can be reasonably appraised under a wide variety of as-yet-undefined future conditions – enabling modeling and analyses of the potential benefit of various alternative technology pathways.

B. Strategy

NETL will use a log-based, gas-in-place approach to provide an unprecedented level of geographic and stratigraphic detail. Detailed dissaggregation of the resource into thousands of uniquely characterized segments that reflect the natural variety in key geologic and engineering parameters is achieved through the analysis of hundreds of well log suites, well production histories, and other pertinent information. Ultimately, these assessments will aim to understand the nature of the existing resource that lies outside the limits of current economic recoverability. This understanding will enable NETL to identify priority basins and plays for further analysis of the potential role of technology advances in generating significant expansions in resource recoverability.

Specifically, this effort will focus on and include:

- *Resource Characterizations* – Conduct detailed regional geologic analyses (including detailed geologic mapping, interpretation of depositional systems and resultant reservoir trends and geometries, and well-log analysis to determine the aerial variations in critical reservoir parameters) of targeted resource elements in mature basins such as the Appalachian. The work will quantify the nature and volume of emerging, overlooked, or underutilized resources, and will present these data through high-quality regional geologic maps, cross-sections, and databases.
- *Technology Assessments* –Analyze the results of these resource characterizations to identify opportunities where technological advances could unlock currently untapped resources, and refine the ability to quantify the impact of potential technological advances on resource recoverability.
- *Technology Transfer* – Work with organizations such as the Petroleum Technology Transfer Council (PTTC), the Stripper Well Consortium (SWC), and

the Small Producers Program with RPSEA to realize the development or adoption of the most promising technologies in areas currently being developed by small independent oil and gas companies.

C. Goals & Objectives

Near Term (by end FY 2008)

1) Assess and identify the most-promising resource elements for characterization within the Appalachian and/or other mature basins. These plays will be those for which there is determined to be significant resources in-place that are poorly characterized or beyond the margins of economic recoverability.
2) Design and initiate a research effort in geologically-based resource assessments targeting the key plays identified above. Collect the available well data and construct a regional network of cross-sections to delineate the area and stratigraphic extent of the identified plays.
3) Work with regional entities, such as the PTTC and SWC, to report on new/innovative technology usage in selected basins (e.g., Appalachian) that encourages faster/broader adoption of potentially high impact advanced technologies.
4) Investigate and enhance modeling capability that enables measurement of the potential impact of technology advances in mature basins.

Intermediate Term (by end 2012)

1) Deliver an initial resource characterization product for selected high-potential plays in the Appalachian basin (by 2010). This product will include a full suite of maps, cross-sections, digitized well logs and reservoir data spreadsheets with accompanying report on methodology to be published on CD in the manner similar to previous NETL assessments. Reports will also be prepared for publication in professional journals.
2) Identify and deliver (by 2012) a second set of assessments on plays yet to-be-determined.
3) Provide an assessment of historical technology utilization in mature basins to determine the potential impacts of federal efforts to accelerate technology utilization.
4) Initiate additional assessments as needed, and have several assessment studies on high priority basins underway in parallel.

Long Term (through fiscal year 2017)

1) Complete four major resource assessment efforts and fully transfer that data to industry and the public.
2) Document instances in which advanced technology utilization in mature basins has been accelerated through the analyses conducted at NETL.

D. Anticipated Results

The Center for Resource Assessment will produce detailed geologic, geophysical, and reservoir/production engineering analyses to assess the potentially large volumes of available, but currently untapped, oil and natural gas resources. Similar to the results

from past NETL assessments, these data will be of great value to the industry, and will also enable NETL to model the impact of technology on resource recovery, particularly emerging and/or unconventional resources. The Center will collaborate with organizations such as the PTTC, as well as regional organizations such as the Penn State SWC, to enhance the utilization and effectiveness of the most promising technologies identified.

Near term results anticipated from this effort include:

- The assessment and identification of the most-promising resource elements for characterization within the Appalachian and/or other mature basins.
- Establishment of a fully staffed research effort in geologically-based resource assessment targeting key unconventional natural gas resources as identified in preceding assessment, described above.
- Deliver an initial resource characterization product for those high-potential plays selected above, Appalachian basin, etc.
- Completion of an assessment of historical technology utilization in the Appalachian Basin and any other target areas selected.
- Production and delivery of reports and products to Industry that respond to the needs of the industry in matching technology to the geological system for the Appalachian Basin and any other assessment areas selected for this initial study.

E. Anticipated Impact

The Center for Resource Assessment will quantify the nature and volume of emerging, overlooked, or underutilized resources, and generate geological and engineering datasets of unprecedented detail. As a result, these datasets allow modelers, as well as E&P entities, to identify priority basins and plays in which advanced technologies may significantly increase domestic resource recoverability.

Future assessments and studies have the potential for the greatest impact in areas of emerging or highly unconventional resources. In areas, such as the Appalachian basin, where industry activity is limited to small independents operators, integrated regional assessments can help identify and/or expedite exploration and technological breakthroughs. Finally, NETL's resource assessment/modeling efforts may lead to the identification of R&D synergies with other key NETL programs, such as the environmental impacts and CO_2 seque

4. Planning and Analysis Support

The Office of Systems, Analyses and Planning (OSAP) performs studies that are focused at the analysis of complex, large systems and of interactions among those systems. These studies are completed using well-established methods and computational tools. The analyses are performed by federal staff and through joint activities with other organizations, DOE laboratories, and support contractors. Taken as a whole, these system studies provide input to decisions on issues such as national plans and programs; resource use, and environmental and energy security policies, research and development; and deployment of energy technologies.

OSAP has structured teams to accomplish these efforts. In brief, these teams are described as follows:

- **Systems** - Perform studies primarily focused on production and processing of fossil fuels and energy and fuel system synthesis and design.
- **Benefits** - Perform both prospective and retrospective benefits studies in support of fossil energy R&D program areas.
- **Trends and Forecasts** - Collect data and perform assessments that relate to energy production and use, and develop scenarios for technology planning activities.

4.1 Strategy

In order to ensure the most prudent use of EPAct Section 999 funds, a robust, accurate, impartial and transparent analysis of program benefits must be undertaken. Beyond benefits determination, *smartly* focused studies must be completed in order to guide R&D efforts to areas that will yield the most value.

4.2 Goals

The goals of this program element are as follows:

1. Develop rational and objective benefit and impact analysis measures for the EPAct 999 R&D program expenditure of public funds
    i. Estimate increases in royalty collections due to the R&D program[1]

[1] *From the provision:* (5) ESTIMATES OF INCREASED ROYALTY RECEIPTS.—The Secretary, in consultation with the Secretary of the Interior, shall provide an annual report to Congress with the President's budget on the estimated cumulative increase in Federal royalty receipts (if any) resulting from the implementation of this subtitle. The initial report under this paragraph shall be submitted in the first President's budget following the completion of the first annual plan required under this subsection.

ii. Estimate increases in domestic production and economic gain, and reductions in environmental impacts associated with widespread deployment of EPAct 999 technologies and processes

2. Complete strategic oil- and natural gas-related analyses in the context of EPAct 999 which will optimally guide future research and support the development of national policy and initiatives.

4.3 Approach

OSAP will be the coordinator for benefit and impact studies for implementation of Section 999. OSAP will collaborate with the RPSEA benefits and impacts teams which will allow for effective information exchange and a coherent systems study approach. Section 2.5 of this document provides detail on the type of benefits assessment effort that is envisioned.

OSAP anticipates designing and completing federal lands-focused analyses for unconventional gas, unconventional petroleum, ultra-deep water, and offshore applications. In addition, oil and natural gas policy type studies and forecasts which tie to federal lands issues, royalty collections, and environmental impacts, (e.g., produced water) will also be included in the OSAP portfolio.

These advanced studies will generally include impact and benefit analysis examining increased reserves, increased oil and gas production, increased federal and state tax revenues, increased oil and gas royalties, job creations, co-benefits, and reduction in the costs of supplying energy services. In addition, microeconomic studies may be completed that examine the impact of Section 999 in making available economic resources that can be allocated to other goods and services.

OSAP's may utilize national models such as the National Energy Modeling System (NEMS) modified for oil and gas royalties, and advanced economic models such as the All Modular Industry Growth Assessment (AMIGA) model. As appropriate, these and other models may be used by OSAP to develop work products fully responsive to the requirements of EPAct 999.

4.4 Implementation Plan

Short Term (to be completed by 2008)

Complete by 12/07

- Develop baseline royalty collections metric and develop a report template/methodology for future Reports to Congress
    - Enhance collaborative relationship with the Department of Interior
    - Further develop *partnership* with RPSEA
    - For the initial report, no increase in royalties will be reported since [RPSEA] awards are expected to be made during the 4th quarter of

CY2007. However, a baseline will be reported along with a conceptual framework of the planned *accounting* methodology.

- Collaborate with NETL SCNGO and RPSEA to ensure adequate data collection efforts are included in consortium awards and that these data are conveyed to OSAP on a mutually agreed upon schedule so that specific benefits can be determined, e.g., increases in formation/play recovery.

- Design an analysis that will determine the value of domestically produced natural gas and/or crude oil, and/or other petroleum resources.

- Initiate an industry data/statistics collection and analysis effort (*environmental scan*) to support updates to the annual management plan and the research that results from that plan.

Complete by 12/08

- Collaboratively with DOI, finalize the methodology for estimating increases in royalty collections based on EPAct 999 expenditures and complete a merit review of the methodology.
    - Ensure RPSEA is a partner
    - Implement the methodology
    - Develop and submit increases in royalty collections report [to Congress]

- Complete an assessment that will determine the value of domestically produced natural gas and/or crude oil, and/or other petroleum resources, and subject the analysis to merit review.
    - Publish results of the analysis

- Design and fully test a *framework* for archiving, manipulating and analyzing RPSEA project data for benefits calculation.
    - Initiate population of the database as data availability allows.

- Collect and analyze data (and report out) on trends, etc. to support updates to the annual management plan and to supplement and guide RPSEA's subsequent round of awards.

Intermediate Term (to be completed by 2012)
Complete by 12/09

- Analyze RPSEA year-1 R&D awards data.
    - In partnership with RPSEA, determine the improvements in productivity, efficiency, etc.
    - Develop report on project benefits

- Develop and submit increases in royalty collections report.

- Collect and analyze data (and report out) on trends, etc. to support updates to the annual management plan and to supplement and guide RPSEA's subsequent round of awards.

- Develop and complete a strategic analysis of domestic oil and/or natural gas production in the context of water resources, greenhouse gas emissions/sequestration, and/or *sustainability*.

Complete by 12/10, 12/11, and 12/12

- To be defined in the next update of this management plan.

Acronyms

AMIGA	All Modular Industry Growth Assessment
BOD	Board of Directors
CBNG	coal bed natural gas
CDUEC	Center for Drilling Under Extreme Conditions
CEI	Center for Environmental Impacts
CEUOR	Center for Enhanced and Unconventional Oil Recovery
DOE	Department of Energy
E&P	Exploration and Production
EAG	Environmental Advisory Group
EIA	Energy Information Administration
EOR	enhanced oil recovery
EPA	Environmental Protection Agency
EPAct	Energy Policy Act
GIS	geographic information system
GTI	Gas Technology Institute
HPHT	high pressure and high temperature
LIDAR	light detection and ranging
MMS	Minerals Management Service
MMV	measuring, monitoring, and verification
NEMS	National Energy Modeling System
NETL	National Energy Technology Laboratory
NMT	New Mexico Tech University
NPC	National Petroleum Council
O&G	oil & gas
OCI	Organizational Conflict of Interest Plan
OCS	Outer Continental Shelf
ORD	Office of Research and Development
OSAP	Office of Systems, Analysis and Planning
PAC	Program Advisory Committee
PTTC	Petroleum Technology Transfer Council
RAG	Research Advisory Group
RFP	Request for Proposal
ROP	rate of penetration
RPSEA	Research Partnership to Secure Energy for America
S1	Solicitation 1 of 3 planned for Ultra-Deepwater
S2	Solicitation 2 of 3 planned for Ultra-Deepwater
S3	Solicitation 3 of 3 planned for Ultra-Deepwater
SAC	Strategic Advisory Committee
SAIC	Science Applications Internationational Corporation
SCNGO	Strategic Center for Natural Gas and Oil
SDI	subsurface drip irrigation
SWC	Stripper Well Consortium
TAC	Technical Advisory Committee

TCF	trillion cubic feet
TVD	total volume daily
UDS	Ultra-deep single cutter Drilling Simulator
UDW	Ultra-Deepwater

Appendix A: EPAct 2005 - Section 999

Subtitle J--Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Resources

SEC. 999A. PROGRAM AUTHORITY.

(a) *In General*.--The Secretary shall carry out a program under this subtitle of research, development, demonstration, and commercial application of technologies for ultra-deepwater and unconventional natural gas and other petroleum resource exploration and production, including addressing the technology challenges for small producers, safe operations, and environmental mitigation (including reduction of greenhouse gas emissions and sequestration of carbon).

(b) *Program Elements*.--The program under this subtitle shall address the following areas, including improving safety and minimizing environmental impacts of activities within each area:

(1) Ultra-deepwater architecture and technology, including drilling to formations in the Outer Continental Shelf to depths greater than 15,000 feet.

(2) Unconventional natural gas and other petroleum resource exploration and production technology.

(3) The technology challenges of small producers.

(4) Complementary research performed by the National Energy Technology Laboratory for the Department.

(c) *Limitation on Location of Field Activities*.--Field activities under the program under this subtitle shall be carried out only--

(1) in--

(A) areas in the territorial waters of the United States not under any Outer Continental Shelf moratorium as of September 30, 2002;

(B) areas onshore in the United States on public land administered by the Secretary of the Interior available for oil and gas leasing, where consistent with applicable law and land use plans; and

(C) areas onshore in the United States on State or private land, subject to applicable law; and

(2) with the approval of the appropriate Federal or State land management agency or private land owner.

(d) *Activities at the National Energy Technology Laboratory*.--The Secretary, through the National Energy Technology Laboratory, shall carry out a program of research and other activities complementary to and supportive of the research programs under subsection (b).

(e) *Consultation With Secretary of the Interior*.--In carrying out this subtitle, the Secretary shall consult regularly with the Secretary of the Interior.

SEC. 999B. ULTRA-DEEPWATER AND UNCONVENTIONAL ONSHORE NATURAL GAS AND OTHER PETROLEUM RESEARCH AND DEVELOPMENT PROGRAM.

(a) *In General*.--The Secretary shall carry out the activities under section 999A, to maximize the value of natural gas and other petroleum resources of the United States, by increasing the supply of such resources, through reducing the cost and increasing the efficiency of exploration for and production of such resources, while improving safety and minimizing environmental impacts.

(b) *Role of the Secretary*.--The Secretary shall have ultimate responsibility for, and oversight of, all aspects of the program under this section.

(c) *Role of the Program Consortium*.--

(1) IN GENERAL.--The Secretary shall contract with a corporation that is structured as a consortium to administer the programmatic activities outlined in this chapter. The program consortium shall--

(A) administer the program pursuant to subsection (f)(3), utilizing program administration funds only ;

(B) issue research project solicitations upon approval of the Secretary or the Secretary's designee;

(C) make project awards to research performers upon approval of the Secretary or the Secretary's designee;

(D) disburse research funds to research performers awarded under subsection (f) as directed by the Secretary in accordance with the annual plan under subsection (e); and

(E) carry out other activities assigned to the program consortium by this section.

(2) **LIMITATION**.--The Secretary may not assign any activities to the program consortium except as specifically authorized under this section.

(3) **CONFLICT OF INTEREST**.--

(A) **PROCEDURES**.--The Secretary shall establish procedures--

(i) to ensure that each board member, officer, or employee of the program consortium who is in a decisionmaking capacity under subsection (f)(3) shall disclose to the Secretary any financial interests in, or financial relationships with, applicants for or recipients of awards under this section, including those of his or her spouse or minor child, unless such relationships or interests would be considered to be remote or inconsequential; and

(ii) to require any board member, officer, or employee with a financial relationship or interest disclosed under clause (i) to recuse himself or herself from any oversight under subsection (f)(4) with respect to such applicant or recipient.

(B) **FAILURE TO COMPLY**.--The Secretary may disqualify an application or revoke an award under this section if a board member, officer, or employee has failed to comply with procedures required under subparagraph (A)(ii).

(d) *Selection of the Program Consortium*.--

(1) **IN GENERAL**.--The Secretary shall select the program consortium through an open, competitive process.

(2) **MEMBERS**.--The program consortium may include corporations, trade associations, institutions of higher education, National Laboratories, or other research institutions. After submitting a proposal under paragraph (4), the program consortium may not add members without the consent of the Secretary.

(3) **REQUIREMENT OF SECTION 501(c)(3) STATUS**.--The Secretary shall not select a consortium under this section unless such consortium is an organization described in section 501(c)(3) of the Internal Revenue Code of 1986 and exempt from tax under such section 501(a) of such Code.

(4) **SCHEDULE.--**Not later than 90 days after the date of enactment of this Act, the Secretary shall solicit proposals from eligible consortia to perform the duties in subsection (c)(1), which shall be submitted not later than 180 days after the date of enactment of this Act. The Secretary shall select the program consortium not later than 270 days after such date of enactment.

(5) **APPLICATION**.--Applicants shall submit a proposal including such information as the Secretary may require. At a minimum, each proposal shall--

(A) list all members of the consortium;

(B) fully describe the structure of the consortium, including any provisions relating to intellectual property; and

(C) describe how the applicant would carry out the activities of the program consortium under this section.

(6) **ELIGIBILITY**.--To be eligible to be selected as the program consortium, an applicant must be an entity whose members have collectively demonstrated capabilities and experience in planning and managing research, development, demonstration, and commercial application programs for ultra-deepwater and unconventional natural gas or other petroleum exploration or production.

(7) **FOCUS AREAS FOR AWARDS**.--

(A) **ULTRA-DEEPWATER RESOURCES**.--Awards from allocations under section 999H(d)(1) shall focus on the development and demonstration of individual exploration and production technologies as well as integrated systems technologies including new architectures for production in ultra-deepwater.

(B) **UNCONVENTIONAL RESOURCES**.--Awards from allocations under section 999H(d)(2) shall focus on areas including advanced coalbed methane, deep drilling, natural gas production from tight sands, natural gas production from gas shales, stranded gas, innovative exploration and production techniques, enhanced recovery techniques, and environmental mitigation of unconventional natural gas and other petroleum resources exploration and production.

(C) **SMALL PRODUCERS**.--Awards from allocations under section 999H(d)(3) shall be made to consortia consisting of small producers or organized primarily for the benefit of small producers, and shall focus on areas including complex geology involving rapid changes in the type and quality of the oil and gas reservoirs across the reservoir; low reservoir pressure; unconventional natural gas reservoirs in coalbeds, deep reservoirs, tight sands, or shales; and unconventional oil reservoirs in tar sands and oil shales.

(e) *Annual Plan*.--

(1) **IN GENERAL.--**The program under this section shall be carried out pursuant to an annual plan prepared by the Secretary in accordance with paragraph (2).

(2) **DEVELOPMENT.--**

(A) **SOLICITATION OF RECOMMENDATIONS.--**Before drafting an annual plan under this subsection, the Secretary shall solicit specific written recommendations from the program consortium for each element to be addressed in the plan, including those described in paragraph (4). The program consortium shall submit its recommendations in the form of a draft annual plan.

(B) **SUBMISSION OF RECOMMENDATIONS; OTHER COMMENT.--**The Secretary shall submit the recommendations of the program consortium under subparagraph (A) to the Ultra-Deepwater Advisory Committee established under section 999D(a) and to the Unconventional Resources Technology Advisory Committee established under section 999D(b), and such Advisory Committees shall provide to the Secretary written comments by a date determined by the Secretary. The Secretary may also solicit comments from any other experts.

(C) **CONSULTATION.--**The Secretary shall consult regularly with the program consortium throughout the preparation of the annual plan.

(3) **PUBLICATION.--**The Secretary shall transmit to Congress and publish in the Federal Register the annual plan, along with any written comments received under paragraph (2)(A) and (B).

(4) **CONTENTS.--**The annual plan shall describe the ongoing and prospective activities of the program under this section and shall include--

(A) a list of any solicitations for awards to carry out research, development, demonstration, or commercial application activities, including the topics for such work, who would be eligible to apply, selection criteria, and the duration of awards; and

(B) a description of the activities expected of the program consortium to carry out subsection (f)(3).

(5) **ESTIMATES OF INCREASED ROYALTY RECEIPTS**.--The Secretary, in consultation with the Secretary of the Interior, shall provide an annual report to Congress with the President's budget on the estimated cumulative increase in Federal royalty receipts (if any) resulting from the implementation of this subtitle. The initial report under this paragraph shall be submitted in the first President's budget following the completion of the first annual plan required under this subsection.

(f) *Awards*.--

(1) **IN GENERAL**.--Upon approval of the Secretary the program consortium shall make awards to research performers to carry out research, development, demonstration, and commercial application activities under the program under this section. The program consortium shall not be eligible to receive such awards, but provided that conflict of interest procedures in section 999B(c)(3) are followed, entities who are members of the program consortium are not precluded from receiving research awards as either individual research performers or as research performers who are members of a research collaboration.

(2) **PROPOSALS**.--Upon approval of the Secretary the program consortium shall solicit proposals for awards under this subsection in such manner and at such time as the Secretary may prescribe, in consultation with the program consortium.

(3) **OVERSIGHT**.--

(A) **IN GENERAL**.--The program consortium shall oversee the implementation of awards under this subsection, consistent with the annual plan under subsection (e), including disbursing funds and monitoring activities carried out under such awards for compliance with the terms and conditions of the awards.

(B) **EFFECT**.--Nothing in subparagraph (A) shall limit the authority or responsibility of the Secretary to oversee awards, or limit the authority of the Secretary to review or revoke awards.

(g) *Administrative Costs*.--

(1) **IN GENERAL**.--To compensate the program consortium for carrying out its activities under this section, the Secretary shall provide to the program consortium funds sufficient to administer the program. This compensation may include a management fee consistent with Department of Energy contracting practices and procedures.

(2) **ADVANCE**.--The Secretary shall advance funds to the program consortium upon selection of the consortium, which shall be deducted from amounts to be provided under paragraph (1).

(h) *Audit*.--The Secretary shall retain an independent auditor, which shall include a review by the General Accountability Office, to determine the extent to which funds provided to the program consortium, and funds provided under awards made under subsection (f), have been expended in a manner consistent with the purposes and requirements of this subtitle. The auditor shall transmit a report (including any review by the General Accountability Office) annually to the Secretary, who shall transmit the report to Congress, along with a plan to remedy any deficiencies cited in the report.

(i) *Activities by the United States Geological Survey*.--The Secretary of the Interior, through the United States Geological Survey, shall, where appropriate, carry out programs of long-term research to complement the programs under this section.

(j) *Program Review and Oversight*.--The National Energy Technology Laboratory, on behalf of the Secretary, shall (1) issue a competitive solicitation for the program consortium, (2) evaluate, select, and award a contract or other agreement to a qualified program consortium, and (3) have primary review and oversight responsibility for the program consortium, including review and approval of research awards proposed to be made by the program consortium, to ensure that its

activities are consistent with the purposes and requirements described in this subtitle. Up to 5 percent of program funds allocated under paragraphs (1) through (3) of section 999H(d) may be used for this purpose, including program direction and the establishment of a site office if determined to be necessary to carry out the purposes of this subsection.

SEC. 999C. ADDITIONAL REQUIREMENTS FOR AWARDS.

(a) *Demonstration Projects*.--An application for an award under this subtitle for a demonstration project shall describe with specificity the intended commercial use of the technology to be demonstrated.

(b) *Flexibility in Locating Demonstration Projects*.--Subject to the limitation in section 999A(c), a demonstration project under this subtitle relating to an ultra-deepwater technology or an ultra-deepwater architecture may be conducted in deepwater depths.

(c) *Intellectual Property Agreements*.--If an award under this subtitle is made to a consortium (other than the program consortium), the consortium shall provide to the Secretary a signed contract agreed to by all members of the consortium describing the rights of each member to intellectual property used or developed under the award.

(d) *Technology Transfer*.--2.5 percent of the amount of each award made under this subtitle shall be designated for technology transfer and outreach activities under this subtitle.

(e) *Cost Sharing Reduction for Independent Producers*.--In applying the cost sharing requirements under section 988 to an award under this subtitle the Secretary may reduce or eliminate the non-Federal requirement if the Secretary determines that the reduction is necessary and appropriate considering the technological risks involved in the project.

(f) *Information Sharing*.--All results of the research administered by the program consortium shall be made available to the public consistent with Department policy and practice on information sharing and intellectual property agreements.

SEC. 999D. ADVISORY COMMITTEES.

(a) *Ultra-Deepwater Advisory Committee*.--

(1) ESTABLISHMENT.--Not later than 270 days after the date of enactment of this Act, the Secretary shall establish an advisory committee to be known as the Ultra-Deepwater Advisory Committee.

(2) **MEMBERSHIP**.--The Advisory Committee under this subsection shall be composed of members appointed by the Secretary, including--

(A) individuals with extensive research experience or operational knowledge of offshore natural gas and other petroleum exploration and production;

(B) individuals broadly representative of the affected interests in ultra-deepwater natural gas and other petroleum production, including interests in environmental protection and safe operations;

(C) no individuals who are Federal employees; and

(D) no individuals who are board members, officers, or employees of the program consortium.

(3) **DUTIES**.--The Advisory Committee under this subsection shall—

(A) advise the Secretary on the development and implementation of programs under this subtitle related to ultradeepwater natural gas and other petroleum resources; and

(B) carry out section 999B(e)(2)(B).

(4) **COMPENSATION**.--A member of the Advisory Committee under this subsection shall serve without compensation but shall receive travel expenses in accordance with applicable provisions under subchapter I of chapter 57 of title 5, United States Code.

(b) *Unconventional Resources Technology Advisory Committee*.--

(1) **ESTABLISHMENT**.--Not later than 270 days after the date of enactment of this Act, the Secretary shall establish an advisory committee to be known as the Unconventional Resources Technology Advisory Committee.

(2) **MEMBERSHIP**.--The Secretary shall endeavor to have a balanced representation of members on the Advisory Committee to reflect the breadth of geographic areas of potential gas supply. The Advisory Committee under this subsection shall be composed of members appointed by the Secretary, including--

(A) a majority of members who are employees or representatives of independent producers of natural gas and other petroleum, including small producers;

(B) individuals with extensive research experience or operational knowledge of unconventional natural gas and other petroleum resource exploration and production;

(C) individuals broadly representative of the affected interests in unconventional natural gas and other petroleum resource exploration and production, including interests in environmental protection and safe operations;

(D) individuals with expertise in the various geographic areas of potential supply of unconventional onshore natural gas and other petroleum in the United States;

(E) no individuals who are Federal employees; and

(F) no individuals who are board members, officers, or employees of the program consortium.

(3) **DUTIES**.--The Advisory Committee under this subsection shall--

(A) advise the Secretary on the development and implementation of activities under this subtitle related to unconventional natural gas and other petroleum resources; and

(B) carry out section 999B(e)(2)(B).

(4) **COMPENSATION**.--A member of the Advisory Committee under this subsection shall serve without compensation but shall receive travel expenses in accordance with applicable provisions under subchapter I of chapter 57 of title 5, United States Code.

(c) *Prohibition*.--No advisory committee established under this section shall make recommendations on funding awards to particular consortia or other entities, or for specific projects.

SEC. 999E. LIMITS ON PARTICIPATION.

An entity shall be eligible to receive an award under this subtitle only if the Secretary finds--

(1) that the entity's participation in the program under this subtitle would be in the economic interest of the United States; and

(2) that either--

(A) the entity is a United States-owned entity organized under the laws of the United States; or

(B) the entity is organized under the laws of the United States and has a parent entity organized under the laws of a country that affords--

(i) to United States-owned entities opportunities, comparable to those afforded to any other entity, to participate in any cooperative research venture similar to those authorized under this subtitle;

(ii) to United States-owned entities local investment opportunities comparable to those afforded to any other entity; and

(iii) adequate and effective protection for the intellectual property rights of United States-owned entities.

SEC. 999F. SUNSET.
The authority provided by this subtitle shall terminate on September 30, 2014.

SEC. 999G. DEFINITIONS.

In this subtitle:

(1) **DEEPWATER**.--The term “deepwater” means a water depth that is greater than 200 but less than 1,500 meters.

(2) **INDEPENDENT PRODUCER OF OIL OR GAS**.--

(A) **IN GENERAL**.--The term “independent producer of oil or gas” means any person that produces oil or gas other than a person to whom subsection (c) of section 613A of the Internal Revenue Code of 1986 does not apply by reason of paragraph (2) (relating to certain retailers) or paragraph (4) (relating to certain refiners) of section 613A(d) of such Code.

(B) **RULES FOR APPLYING PARAGRAPHS (2) AND (4) OF SECTION 613A**(d).--For purposes of subparagraph (A), paragraphs (2) and (4) of section 613A(d) of the Internal Revenue Code of 1986 shall be applied by substituting `"calendar year" for "taxable year" each place it appears in such paragraphs.

(3) **PROGRAM ADMINISTRATION FUNDS**.--The term "program administration funds" means funds used by the program consortium to administer the program under this subtitle, but not to exceed 10 percent of the total funds allocated under paragraphs (1) through (3) of section 999H(d).

(4) **PROGRAM CONSORTIUM**.--The term "program consortium" means the consortium selected under section 999B(d).

(5) **PROGRAM RESEARCH FUNDS**.--The term "program research funds" means funds awarded to research performers by the program consortium consistent with the annual plan.

(6) **REMOTE OR INCONSEQUENTIAL**.--The term "remote or inconsequential" has the meaning given that term in regulations issued by the Office of Government Ethics under section 208(b)(2) of title 18, United States Code.

(7) **SMALL PRODUCER**.--The term "small producer" means an entity organized under the laws of the United States with production levels of less than 1,000 barrels per day of oil equivalent.

(8) **ULTRA-DEEPWATER**.--The term "ultra-deepwater" means a water depth that is equal to or greater than 1,500 meters.

(9) **ULTRA-DEEPWATER ARCHITECTURE**.--The term "ultra-deepwater architecture" means the integration of technologies for the exploration for, or production of, natural gas or other petroleum resources located at ultra-deepwater depths.

(10) **ULTRA-DEEPWATER TECHNOLOGY**.--The term "ultra-deepwater technology" means a discrete technology that is specially suited to address 1 or more challenges associated with the exploration for, or production of, natural gas or other petroleum resources located at ultra-deepwater depths.

(11) **UNCONVENTIONAL NATURAL GAS AND OTHER PETROLEUM RESOURCE**.--The term "unconventional natural gas and other petroleum resource" means natural gas and other petroleum resource located onshore in an economically inaccessible geological formation, including resources of small producers.

SEC. 999H. FUNDING.

(a) *Oil and Gas Lease Income*.--For each of fiscal years 2007 through 2017, from any Federal royalties, rents, and bonuses derived from Federal onshore and offshore oil and gas leases issued under the Outer Continental Shelf Lands Act (43 U.S.C. 1331 et seq.) and the Mineral Leasing Act (30 U.S.C. 181 et seq.) which are deposited in the Treasury, and after distribution of any such funds as described in subsection (c), $50,000,000 shall be deposited into the Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Research Fund (in this section referred to as the ``Fund''). For purposes of this section, the term ``royalties'' excludes proceeds from the sale of

royalty production taken in kind and royalty production that is transferred under section 27(a)(3) of the Outer Continental Shelf Lands Act (43 U.S.C. 1353(a)(3)).

(b) *Obligational Authority*.--Monies in the Fund shall be available to the Secretary for obligation under this part without fiscal year limitation, to remain available until expended.

(c) *Prior Distributions*.--The distributions described in subsection (a) are those required by law--

(1) to States and to the Reclamation Fund under the Mineral Leasing Act (30 U.S.C. 191(a)); and

(2) to other funds receiving monies from Federal oil and gas leasing programs, including--

(A) any recipients pursuant to section 8(g) of the Outer Continental Shelf Lands Act (43 U.S.C. 1337(g));

(B) the Land and Water Conservation Fund, pursuant to section 2(c) of the Land and Water Conservation Fund Act of 1965 (16 U.S.C. 4601-5(c));

(C) the Historic Preservation Fund, pursuant to section 108 of the National Historic Preservation Act (16 U.S.C. 470h); and

(D) the coastal impact assistance program established under section 31 of the Outer Continental Shelf Lands Act (as amended by section 384).

(d) *Allocation*.--Amounts obligated from the Fund under subsection (a)(1) in each fiscal year shall be allocated as follows:

(1) 35 percent shall be for activities under section 999A(b)(1).

(2) 32.5 percent shall be for activities under section 999A(b)(2).

(3) 7.5 percent shall be for activities under section 999A(b)(3).

(4) 25 percent shall be for complementary research under section 999A(b)(4) and other activities under section 999A(b) to include program direction funds, overall program oversight, contract management, and the establishment and operation of a technical committee to ensure that in-house research activities funded under section 999A(b)(4) are technically complementary to, and not duplicative of, research conducted under paragraphs (1), (2), and (3) of section 999A(b).

(e) *Authorization of Appropriations*.--In addition to other amounts that are made available to carry out this section, there is authorized to be appropriated to carry out this section $100,000,000 for each of fiscal years 2007 through 2016.

(f) *Fund*.--There is hereby established in the Treasury of the United States a separate fund to be known as the ``Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Research Fund".

Appendix B: RPSEA Membership and Committee Lists

RPSEA Members (as shown on website)

ACERGY US*(PENDING)*
ACUTE TECHNOLOGY SERVICES *(PENDING)*
ADVANCED RESOURCES INTERNATIONAL
AEROVIRONMENT
ALTIRA GROUP
AMERICAN GAS ASSOCIATION
ANADARKO PETROLEUM CORPORATION
APACHE CORPORATION
APEX METALINK
BILL BARRETT CORPORATION
BP AMERICA
BREITBURN ENERGY
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CHESAPEAKE ENERGY
CHEVRON CORPORATION
CITY OF SUGAR LAND
COLORADO ENERGY RESEARCH INSTITUTE/COLORADO SCHOOL OF MINES
CONOCOPHILLIPS
CONSERVATION COMMITTEE OF CALIFORNIA OIL & GAS PRODUCERS
CRANE CORPORATION
CSI TECHNOLOGIES *(PENDING)*
DET NORSKE VERITAS (USA)
DEVON ENERGY CORPORATION
DYNAMIC TUBULARS
ENERCREST *(PENDING)*
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ENERGY VALLEY
ERGON EXPLORATION
(THE) FLEISCHAKER COMPANIES
FLORIDA INTERNATIONAL UNIVERSITY
GAS TECHNOLOGY INSTITUTE
GE/VETCO
GEOTRACE TECHNOLOGIES
GREATER FORT BEND ECONOMIC DEVELOPMENT COUNCIL
GROUNDWATER SERVICES
HALLIBURTON ENERGY SERVICES
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INDEPENDENT PETROLEUM ASSOCIATION OF AMERICA
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INTERSTATE OIL AND GAS COMPACT COMMISSION
JACKSON STATE UNIVERSITY
JOHNSON PERFORMANCE
K. STEWART ENERGY GROUP
LAWRENCE BERKELEY NATIONAL LABORATORY
LAWRENCE LIVERMORE NATIONAL LABORATORY
LOS ALAMOS NATIONAL LABORATORY
LOUISIANA STATE UNIVERSITY
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OXANE MATERIALS *(PENDING)*
PENN STATE UNIVERSITY
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STATOIL GULF OF MEXICO
STRATA PRODUCTION COMPANY
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TEXAS INDEPENDENT PRODUCERS & ROYALTY OWNERS ASSOCIATION
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UTAH GEOLOGICAL SURVEY
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UTE INDIAN TRIBE
WEATHERFORD
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WEST VIRGINIA UNIVERSITY
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Mr. Thomas E. Williams	Noble Drilling Corporation
Mr. C. Michael Ming – RPSEA President	RPSEA

RPSEA Strategic Advisory Committee (SAC)

Strategic Advisory Committee Member	Affiliation
John Allen	GE/Vetco
Ralph Cavanagh	Natural Resources Defense Council
Peter Dea	Independent
Steven Holditch	Texas A&M University
Melanie Kenderdine	Gas Technology Institute
Vello Kuuskraa	Advance Resources International
Daniel Lopez	New Mexico Institute of Mining & Technology
Dirk McDermott	Altira Group
Michael Ming	RPSEA
Ernest Moniz	Massachusetts Institute of Technology
Mark Murphy	Strata Production
Donald Paul	Chevron
William Schneider	Newfield Exploration

RPSEA Ultra-Deepwater PAC

Name	Organization
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Gail Baxter	Marathon
Mike Grecco	Chevron
Ron Araujo	Anadarko
Bal Dhami	Total
Arnt Olufsen	Statoil
Luiz Souza	Petrobras
Maurizio Zecchin	ENI
Tom Williams	Noble Corporation (ex-officio)
Gary Covatch	NETL (ex-officio)
Roy Long	NETL (ex-officio)

RPSEA Unconventional Onshore PAC

Name	Company
Darrell Pierce	DCP Midstream, LLC
Steve McKetta	El Paso Corporation
Mark Malinowski	Rosewood Resources, Inc.
David Martinueau	Pitts Energy
Steve Sonnenberg	Anadarko Petroleum Corporation
Bill Van Wie	Devon Energy Corporation
John Lewis	Noble Energy
Mark Glover	BP America
Julio Friedman	Lawrence Livermore National Lab
Mark Murphy	Strata Production Company
Kurt Reinecke	Bill Barrett Corp.
Bob Boswell	Laramie Energy
Dr. John Lee	Texas A&M University
Bob Stayton	Weatherford International Ltd.
Dr. Valerie Jochen	Schlumberger Limited
Dr. Dag Nummedal	Colorado School of Mines (CERI)
Dr. Nafi Toksoz	Massachusetts Institute of Technology
Roy Long	DOE (NETL), Ex-Officio
Virginia Weyland	DOE (NETL) Ex-Officio

Small Producer Research Advisory Group

Name	Organization
Mark Murphy, Chair	Strata Production, Roswell, NM
Brook Phifer, Vice Chair	Nico Resources, Denver, CO
Bob Kiker	PTTC Permian Basin, Midland, TX
Chuck Boyer	Schlumberger, Pittsburgh, PA
Douglas Patchen	WVU, Morgantown, WV
Iraj Irshaghi	USC, Los Angeles, CA
Ben Hare	Panhandle Royalty, Oklahoma City, OK
TBD	Small Producer, Gulf coast, LA or AL
Roy Long	DOE (NETL), Ex-Officio
Chandra Nautiyal	DOE (NETL), Ex-Officio

Environmental Advisory Group

Name	Organization
Dr. Rich Haut Chairman	Houston Advanced Research Council
Dr. Steve Bryant	University of Texas
Dr. David Burnett	Texas A&M University
Bob Gordan	Stress Engineering
Russ Johns	University of Texas
Pam Matson	Stanford University
Chuck Newell	Groundwater Services
Scitt Reeves	Advanced Resources, Inc.
Øyvind Strøm	Statoil (Houston)
Mason Tomson	Rice University
Scott Anderson	Environmental Defense
Sharon Buccino	NRDC
Assheton Carter	Conservation International
Joe Kiesecker	The Nature Conservancy

Appendix C: RPSEA Draft Plan Document

The following 112 pages encompass the original RPSEA Draft Annual Plan submission.

RPSEA

Draft Annual Plan

April, 2007

www.RPSEA.org

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Section 1

ANNUAL PLAN OVERVIEW

RPSEA Mission, Goals and Objectives

The primary mission of the Research Partnership to Secure Energy for America ("RPSEA") is mandated in Section 999 of the Energy Policy Act 2005 ("EPACT").

RPSEA Mission

RPSEA's mission is to manage …

"….a program of "research, development, demonstration, and commercial application of technologies for ultra-deepwater and unconventional natural gas and other petroleum resource exploration and production, including addressing the technology challenges for small producers, safe operations, and environmental mitigation (including reduction of greenhouse gas emissions and sequestration of carbon".

All RPSEA activities contemplated in this draft Annual Plan (Plan) are focused on achieving this mission. This inaugural Plan is RPSEA's first step towards meeting the more specific goal in EPACT of *"[maximizing] the value of natural gas and other petroleum resources of the United States, by increasing the supply of such resources, through reducing the cost and increasing the efficiency of exploration for and production of such resources, while improving safety and minimizing environmental impacts."*

RPSEA is directed by statute to conduct a program of research, development, demonstration and commercialization ("Program") in two of the nation's most promising – but technically challenged – natural gas and petroleum resource areas:

- Ultra-deepwater ("UDW") integrated system technologies and architectures for water depths in excess of 1,500 meters or drilled depths greater than 15,000' in the Outer Continental Shelf
- Unconventional natural gas and other petroleum resource exploration and production technology, with unconventional being defined as "economically inaccessible." This resource based prioritized research program focuses on converting technically recoverable tight gas sands, coalbed methane and gas shales resources to economic gas production.

Further, RPSEA is required to specifically address the unique technology challenges of small producers through a consortia approach. This research component is focused on advancing technologies for mature oil and gas fields. Small producers are defined as those with production of less than 1,000 BOEPD.

Proactively embedded in the Plan and cross-cutting all elements of the program is a focus on the environment, including projects that minimize or mitigate environmental impact or risk, mitigate water usage, reduce the "footprint", and lower emissions. In addition, technically-driven projects will be measured for environmental impacts – both positive and negative -- to ensure that these impacts are fully understood.

RPSEA's Strategic Advisory Committee recommends that plans for mitigating environmental impacts be included as an evaluation criterion for all research proposals.

Research Program Development Principles

It is the obligation of RPSEA and the goal of this Plan to appropriately balance the critical research needs of the program with the capabilities of the research community and, in so doing, meet its responsibility to the American public -- developing technologies to enhance domestic energy supplies in environmentally responsible ways.

In the United States energy demand is growing at the same time the domestic natural gas and oil industry is transitioning from *"harder to find and easier to produce conventional reservoirs,"* to "*easier to find and harder to produce unconventional reservoirs*." The result has been increased imports, higher prices and declines in conventional domestic natural gas and oil production. The United States however is not resource poor but rather resource long and *technology* short. This technology dearth, in turn, places substantial new demand on the nation's research infrastructure to meet the challenge of developing the portion of the resource base addressed in this Plan for the Ultra-Deepwater and Unconventional Onshore resources. As described in subsequent sections, the targeted resources approach 10 billion barrels of oil and 300 trillion cubic feet of natural gas out of a total described resource base of 50 billion barrels of oil and 1200 trillion cubic feet of natural gas.

As recommended in the National Petroleum Council's (NPC) 1999 Natural Gas Supply Study, *"the government should continue investing in research and development through collaborations with industry, state organizations, national laboratories, and universities."* The research collaboration envisioned in this program is critical; integrating these diverse but capable sectors in the energy research value chain represents one of the largest challenges for the program as well as one of its greatest potential rewards.

RPSEA's mission cannot be achieved without a vibrant and diverse scientific and technical workforce.

It is important that a fundamental point be understood prior to discussing other guiding principles for RPSEA's portfolio development: the program mission *cannot* be achieved without

a vibrant and diverse technical workforce of scientists and engineers. This necessarily entails a strong *organizational* commitment to the academic and research community and a program *structure* that specifically enables their unique problem-solving and innovation capabilities. This robust research and development emphasis also supports the nation's intellectual capital, helping to maintain America's global technological leadership position, as the universities are the training ground and consequently the source for this skilled workforce.

It is also critical to acknowledge the importance of collaborative partnership with industry to the success of the mission -- academic research while absolutely necessary, is clearly not sufficient. Along with other research institutions, industry as the ultimate end user investing in the application of the technologies developed in this program, must play a key and in many instances, the lead role in technology development, particularly as projects move to the development and demonstration phase.

RPSEA's research portfolio will include projects that focus on near-, mid- and longer-term time-scales. It will seek to mitigate research investment risks by building upon early successes, and provide stringent mechanisms for additional development or stage gate termination. RPSEA's portfolio of projects will specifically seek to:

- Create leverage wherever possible on funding, personnel, equipment, operations, and other resources
- Create synergies through integration or investments in cross-cutting and enabling technologies, enabling the whole to be greater than the sum of its parts
- Allow for individual project failure, which is a necessary and desirable attribute if properly managed
- Avoid the funding of many small and/or one time projects which generally minimize the potential for high impact results
- Conversely, focus on a relatively fewer number of larger and/or higher potential projects which create legacy opportunities with appropriate provisions for follow on funding and resources
- Provide for coordination with the complementary program administered by NETL to maximize the federal investment in this research program

Finally the program must balance incremental technology developments with breakthrough technologies – the "grand challenges" -- that will have fundamental and lasting impact for energy consumers. This necessarily entails multiple perspectives to identify problems as well as solutions. This Plan must encourage and make provisions for "out of the box" approaches and applications to enable powerful entrepreneurial enterprise and innovation. Further, RPSEA must provide safeguards against "development by committee" and promote a commitment to commercialization, not just technology transfer.

Fostering research that is commercially viable, that enables faster-than-average adoption – will enhance the industry's role as both a "high tech" developer as well as consumer and will help attract the best minds to the energy industry.

RPSEA's Management Approach

RPSEA's approach to the management of this new and important program is intended to provide substantial benefits to American consumers by meeting significant public policy objectives. Key features of this approach include:

- *Broad and deep stakeholder engagement* to accurately identify and expertly execute high-impact research
- *A rigorous technology portfolio management structure* to align programs, projects, technologies, and technology transfer with the high-level strategic objectives of the statute
- *Integration of diverse program elements* into a cohesive and coherent program that maximizes programmatic impacts
- *Aggressive, informed, and effective technology transfer* focused on each step of the technology maturation process to ensure maximum technology penetration and diffusion in the marketplace

These key features of RPSEA's organization are illustrated below showing the broad process of engagement, both internally and externally.

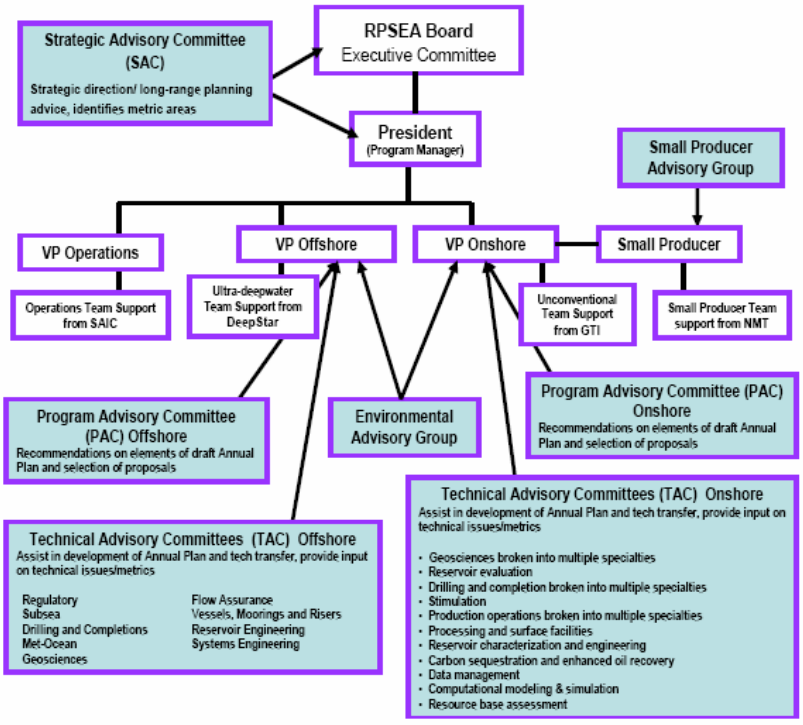


Figure 1.1

Fundamental to the broad and deep stakeholder engagement is the diverse representation on the Board of Directors ("BOD") and the external advisory committees and groups, whose roles are described below:

Board of Directors
RPSEA has a diverse BOD who's members are each renowned for their expertise and give RPSEA extraordinary guidance. The current membership of the BOD is presented in Appendix A. In addition to operational oversight, the BOD provides significant input and direction in the preparation of this Plan, and a two thirds super majority vote is required for Plan approval.

Strategic Advisory Committee
RPSEA established the Strategic Advisory Committee (SAC) to provide strategic direction, advice on the shape of the research portfolio, long range planning recommendations, and metrics determination to the BOD and to the President. Similar to the BOD the SAC is comprised of a group of industry leaders in the energy field, including both RPSEA members and non RPSEA members, who are also listed in Appendix A. The SAC provided guidance regarding the process used to develop the Plan, the shape of the portfolio, and the metrics to be used to track progress toward program goals.

Environmental Advisory Group
Environmental stewardship is at the core of all RPSEA activities. The Environmental Advisory Group (EAG) is designed to provide all program elements with advice regarding environmental issues. The committee will be comprised of a diverse group of experts and policy leaders in this area.

Program Advisory (PACs) and Technical Advisory (TACs) Committees
The roles of the PACs and the TACs are described in the respective sections of this Plan as their process is specific to their program element. Generally the PACs provide recommendations on elements of the Plan but primarily review proposals and make project selections. The TACs provide subject specific technical advice on the development of the Plan and on proposal reviews at the direction of the PACs.

Annual Plan Organization

This inaugural Plan serves as both a ten year strategic plan and an initial annual plan for years one and two of the program, defining the relationship of early research both in short term results and as the foundation for longer term research and projects. In each program section the long term resource analysis is provided followed by the research approach which is then narrowed down into the current year annual research plan.

Conceptually, the Plan is organized as follows:

- Identification of resource targets;
- The proposed research program themes to address these targets, to include one to two, two to five, and five to ten year time scales and associated research plans
- Identification of the key inputs and processes used to determine these targets and program elements
- Risks/barriers and proposed measures to minimize or eliminate these risks

Sections 2, 3 and 4 of the Plan describe the Ultra-Deepwater, Unconventional Onshore and Small Producer Program Element Goals and Objectives, as well as the specific technology development plans for the 2007-2008 fiscal years. Section 5 describes the approach to

determining the impact of the program on energy supplies in the United States. Finally, relevant supporting material is included in the appendices.

In order to insure maximum program effectiveness commensurate with the public resources committed to conduct the program, RPSEA has narrowed the scope to eight major theme areas:

- Four Ultra-Deepwater field types;
- Three Unconventional Onshore resource types, and;
- One Small Producer technology challenge.

The UDW program utilized four general UDW Gulf of Mexico discovery field types as case studies based on actual exploration results. These field types broadly represent the actual challenges that operators face as they seek to make new discoveries, commercialize smaller finds, and move from discovery to production, hence the emphasis on integrated system technologies and architectures as prescribed by EPACT. The sub themes under these four major themes are broad and all inclusive as the technology needs in progressively deeper water require all technology needs to be addressed to help ensure that a "weak link" does not negate subsequent efforts.

The Unconventional Onshore program focused on three priority resource types: gas shales, coal bed methane, and tight gas sands. While other unconventional resource possibilities exist for research, prioritization provides the opportunity for meaningful results versus a diluted non-focused program with little chance of meaningful results in any specific area. This program is appropriately resource focused as defined by EPACT, and in contrast to UDW's all-inclusive technology and architecture portfolio.

The Small Producer program concentrates on the one ubiquitous, widely held, and very high potential asset, namely that of maturing fields. This singular technology focus will enable RPSEA to address the needs of small producers within the funding constraints established in EPACT through a program entitled "Advancing Technology for Mature Fields," as small producers with little or no research and technology development capability are now the primary asset owner of many maturing fields that they either have developed or acquired from larger entities who historically did have such research and technology capabilities.

Each program is uniquely different and the process utilized to address these unique needs is described in the following section, and also depicted in Figure 1.4.

Annual Plan Development Process

In development of this Plan, RPSEA has received input from its 100 plus member organizations as well as from a broad spectrum of additional experts in industry, academia, research organizations, non-governmental organizations, the financial community, consumer organizations, and others which reflect the broad skills, expertise, capability, network, and geographic diversity of the RPSEA membership.

The Plan has been written by RPSEA in consultation with its BOD. In addition input has been provided by the National Energy Technology Laboratory ("NETL") throughout the process. The Plan has been approved by a two thirds super majority vote of the BOD as required by RPSEA's bylaws; this is designed to ensure broad support from the stakeholder community and to protect

against dominance of specialized interests. Specific steps in the development of the Plan include input solicited and/or developed from:

- 11 RPSEA Member Forums in various regions of the country. While RPSEA members hosted the forums, participation was not limited to RPSEA members. Member Forums had 613 individual participants representing 193 organizations with interests in technologies to enhance domestic natural gas and oil production.
- Universities as hosts of all the RPSEA Member Forums. In the UDW process nearly 50 individuals representing over a dozen universities have registered or participated in TAC meetings, and universities are represented on the Unconventional Onshore PAC, uniquely contributing to each program element.
- Multiple individual meetings and contacts with individual RPSEA members.
- RPSEA's UDW and Unconventional Onshore PACs, and the Small Producer RAG for general guidance.
- RPSEA's UDW TAC meetings.
- RPSEA's SAC for high-level strategic, programmatic and portfolio design advice to RPSEA and its program officers.
- Multiple roadmapping exercises conducted by DOE, RPSEA, and others prior to 2007.

SAC recommendations on the general focus of RPSEA's research portfolio are depicted in Figure 1.2, "Portfolio Guidance."

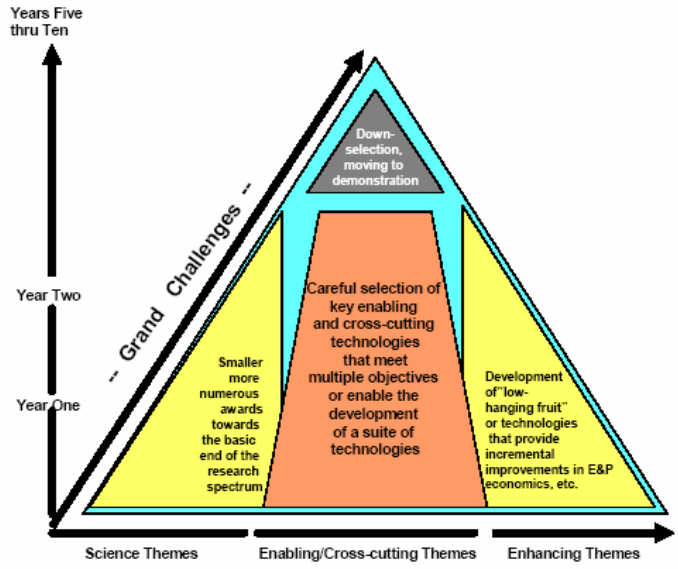


Figure 1.2. Strategic Advisory Committee Research Portfolio Guidance

Figure 1.3 describes detailed steps leading to the development of the Plan. It should be noted that this is an iterative process – both initially and over time -- that is not precisely linear. Figure 1.3 does however detail the totality of the steps and inputs RPSEA has employed to produce the Plan.

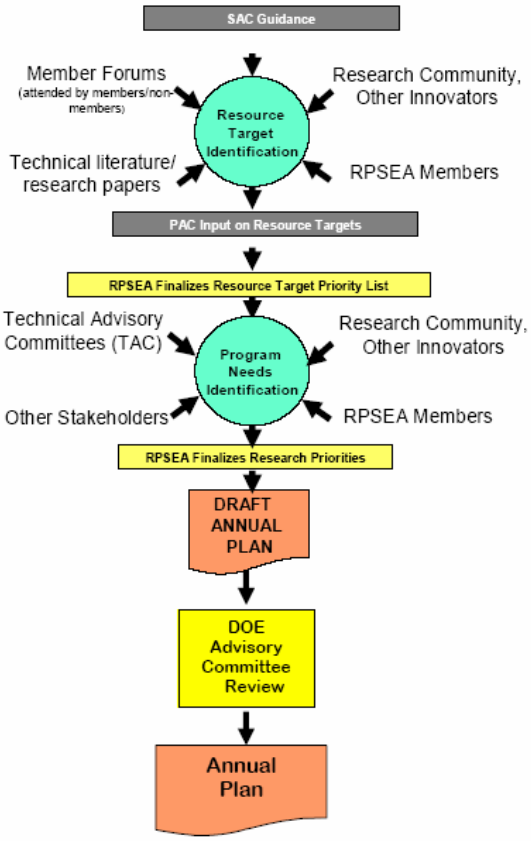


Figure 1.3. Annual Plan High-Level Process Flow and Inputs into Resource Targets/Resource Needs

While RPSEA has established a generic process to identify resource targets, opportunities, barriers, research themes and thrusts and the research plan, there are process differences among the program elements. Figure 1.4 details these variations in industry structure and the ramifications for RPSEA management in the development of the Plan.

	Industry Structure	Research Management Implications
Ultra-Deepwater Program	• Relatively small number of industry players • Significant capital requirements • Consistent regulatory environment • Some internal research capability • Ready adoption of new technology • Very high cost high risk working environment	• Focus on infrastructure/ harsh environmental conditions • Setting priorities with industry input critical to success • Potential to provide significant cash matching funds • Demonstration is very expensive. High value on risk avoidance forces limited number of focus areas • Formal collaborative research model exists
Unconventional Onshore Program Element	• Large number of players, some very small • Limited access to capital • Multiple regulatory jurisdictions • Limited internal research capability • Ability to adopt new technology varies • Technology issues vary considerably with geographic/ geologic area.	• Focus on production/geology/environmental issues • Need to identify and pursue specific resource targets • Little potential for cash matching funds but history of in-kind contributions • Formal tech transfer mechanisms exist • Historical but not current formal collaborative research model • Research programs need to be designed with geographic area and technology user in mind.
Small Producer Program Element	• Number of small producers is 10,000 and growing • Limited access to capital • Multiple regulatory jurisdictions • No internal research capability • Most do not have capability to internalize new technology. • Small producers are threatened by technical, environmental, and market challenges	• Focus on geology, environmental, regulatory compliance, cost reduction • Must work with small producers to identify issues that impact small producers across and within regions • Little potential for cash matching funds but history of in-kind contributions • Formal tech transfer mechanisms exist • Some successful examples of collaborative research exist • Small producers may lack the staff to internalize complicated technology, so tech transfer must involve appropriate service providers.

Figure 1.4. Variations by Program Element

General Consortium Organization

RPSEA is a 501(c)3 non-profit corporation structured as a consortium and selected by the DOE to manage the program under Section 999. Information on RPSEA and its members can be found at www.rpsea.org, and membership is depicted in Appendix E.

As recommended by the National Petroleum Council, RPSEA uses a collaborative approach with industry, academia, and government to advance technology. RPSEA membership includes producing & exploration corporations, service companies, research organizations, universities, national labs, financial entities, non-governmental organizations, and consumer and civic organizations.

RPSEA members represent virtually all critical elements of the natural gas and oil supply technology value chain. This aggregation of knowledge and capability creates a new collaborative technology development network that has never before existed in this industry. This "network of networks" avoids "re-inventing the wheel" by utilizing and leveraging the robust individual capabilities of the network components.

RPSEA's experienced research and project management team, its technical expertise, and a unique and comprehensive approach sharply and directly focus on meeting the critical energy needs of the nation through the development of new technologies.

RPSEA has been operating as a consortium for almost 5 years, managing a portfolio of research projects that are highly relevant to this program. Additionally, RPSEA has contracted with four leading organizations, DeepStar, GTI, SAIC, and New Mexico Tech University ("NMT"), as its management team, whom each have extensive expertise and experience managing similar type programs.

RPSEA will utilize this experience and skill set in its approach to planning and managing the current program.

The skill set includes:

- *Significant experience* in project solicitation, selection, and execution.
- *An established research management process* that promotes fair and open competition employs an objective selection process, and, when necessary, uses external peer review to avoid conflicts of interest.
- *A track record* of industry and academic engagement and participation.
- *An ability to accelerate program startup* and promote early program successes.

RPSEA will also work to educate both the professionals in the upstream oil and gas business and the general public on the issues surrounding technology development and deployment, and the corresponding public benefits. RPSEA will –

RPSEA will be instrumental in advancing the "high technology" aspects of the natural gas and oil exploration and production industries sufficient to attract the best young minds in the energy technology industry

- Work with industry to enhance technology transfer and deployment, demonstrating technology utilization as technologies are developed
- Encourage public appreciation of the natural gas and oil industry as both an innovator and consumer of technology solutions – a high-paying, high impact, technology-driven industry that is global in scope and attractive to the next generation of energy technologists.

Section 2

ULTRA-DEEPWATER PROGRAM ELEMENT

UDW Mission

The mission of the RPSEA Ultra-Deepwater (UDW) Program is to "maximize the value of natural gas and other petroleum resources of the United States by increasing the supply of such resources, through reducing the cost and increasing the efficiency of exploration for and production of such resources, while improving safety and minimizing environmental impact." This is to be accomplished by facilitating a cooperative, focused effort to identify and develop economically viable (full life cycle), acceptable risk technologies, architectures, and methods to explore, drill and produce hydrocarbons from UDW and formations in the Outer Continental Shelf (OCS) deeper than 15,000 feet. Relevant EPACT definitions include:

- Deepwater -- a water depth that is greater than 200 but less than 1,500 meters.
- Ultra-deepwater -- a water depth that is equal to or greater than 1,500 meters.
- Ultra-deepwater Architecture -- the integration of technologies for the exploration for, or production of, natural gas or other petroleum resources located at UDW depths.
- Ultra-deepwater technology --a discrete technology that is specially suited to address one or more challenges associated with the exploration for, or production of, natural gas or other petroleum resources located at UDW depths.

Resource Opportunities and Priorities

There is significant ultra-deepwater resource *potential* in the United States. The Department of Interior's Minerals Management Service (MMS) indicates that there is more than 50 billion recoverable BOE remained to be discovered in the GOM in both deepwater and UDW regions.[1]

Quantifying the potential impact of these discoveries even at a 'resource base' level is quite daunting. Figure 2.1 depicts MMS-known resource estimates and industry-announced discoveries to the proved and unproved reserve volumes. While the industry-announced discovery volumes contain considerable uncertainty, are based on limited drilling, and include numerous assumptions such as sufficiently high commodity pricing to support development, availability of new enabling technology, and regulatory approval, this figure illustrates the potential size of the resource base to be transformed to proven reserves. Figure 2.2 illustrates the distribution of recent hydrocarbon additions in the GOM, categorized by water depth. The combination of industry-announced deepwater discoveries and MMS estimates illustrates that deepwater exploration is adding significantly to the GOM hydrocarbon resource base.

[1] Deepwater Gulf of Mexico 2006:America's Expanding Frontier; OCS report MMS 2006-022

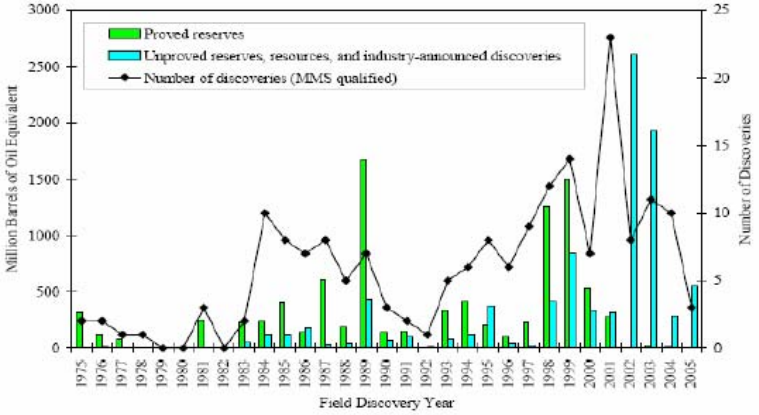


Figure 56. Number of deepwater field discoveries and new hydrocarbons found (MMS reserves, MMS resources, and industry-announced discoveries).

Figure 2.1 (MMS Report 2006-022 Figure 56) MMS-known resource estimates and industry-announced discoveries to the proved and unproved reserve volumes.

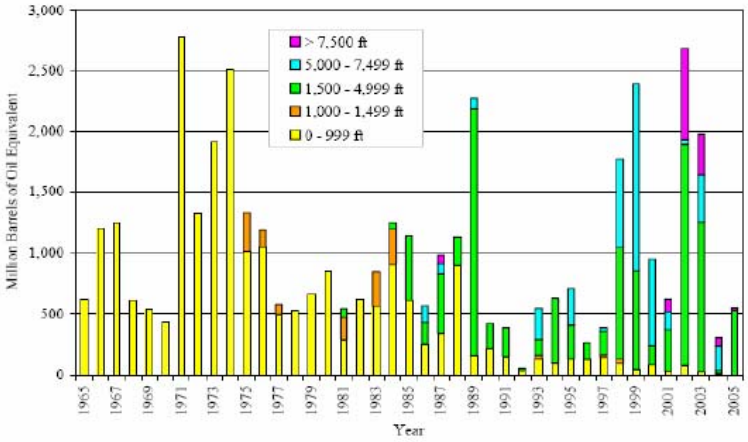


Figure 57. BOE added (reserves, known resources, and industry-announced discoveries).

Figure 2.2 (MMS Report Figure 57) Illustration of the distribution of recent hydrocarbon additions in the GOM, categorized by water depth.

In defining the future resource opportunities of the RPSEA UDW Program, it is instructive to review earlier MMS deepwater reports. Figure 2.3 illustrates continued growth in proved reserves and discovered volumes (which include proved and unproved reserves, resources, and industry-announced discoveries), the progression from *discovered* to *proved* reserves, and the growing differential between discovered volumes and proved reserves. For example, in the 2002 MMS report, Thunder Horse was in the discovered-volumes category, and in the 2004 MMS report its volumes were classified as proved reserves (production continues to be delayed from Thunder Horse, demonstrating the technical difficulties of actually producing oil from "proved" reserves). Clearly, the most dramatic potential for increase lies in development of new enabling and enhancing production technologies that will allow industry to move large volumes of resources into the proved reserves category and ultimately into actual production.

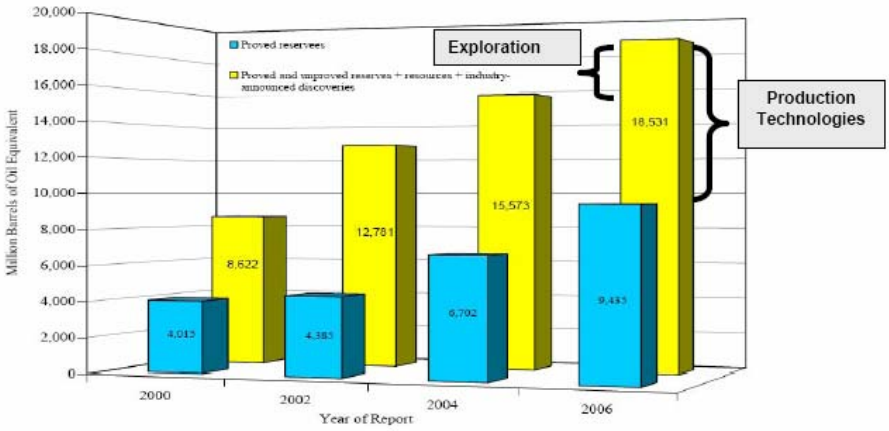


Figure 78. Comparison of 2000, 2002, 2004, and 2006 deepwater GOM reports: successive increases in deepwater BOE.

Figure 2.3 (MMS Report Figure 78) Illustration of the dramatic increases in proved reserves and discovered volumes since 2000

RPSEA's Ultra-deepwater Program

Transforming ultra-deepwater discoveries into producing fields requires huge capital investment and new technologies. RPSEA will focus on:

- *extending basic scientific understanding* of the many UDW challenges as well as developing modeling and predictive tools to help industry better define and ultimately mange the risks associate with field development and physical regimes of the resource base to support efforts in the enabling and enhancing categories

- *developing new enabling and/or cross-cutting technologies* that will allow industry to safely, and in an environmentally friendly manner explore and transform these discoveries into producing properties in ways that are impossible with existing technologies

- *enhancing technologies to help lower the overall cost and risks* and reduce the field development cycle time by improving existing technologies resulting in higher recoveries, lower thresholds of abandonment, and development of currently uneconomic resources. It is instructive to note that even in today's commodity price environment; many large (100 MMBOE plus) fields are not economic due to the current cost of existing technologies and the high level of risk involved with development

- *grand challenges* – transformational technologies which, if successfully developed, are capable of "leapfrogging" over conventional research and development pathways

UDW Goals and Metrics

The primary goal of the RPSEA UDW Program is to increase and produce UDW reserves while protecting the environment, providing the U.S. consumer with secure and affordable petroleum supplies. The RPSEA UDW Program will carry out appropriate activities as delineated in the following sections of this Plan to maximize the value of these resources in order to support America's economic growth, job creation, and its international leadership in energy science and technology by:

1. Increasing the supply of such resources,
2. Reducing the costs to find, develop and produce such resources,
3. Increasing the efficiency of exploration for such resources,
4. Increasing production efficiency and ultimate recovery of such resources,
5. Improving safety, and
6. Improving environmental performance, by reducing any environmental impacts associated with UDW exploration and production.

UDW Program	
Goals	**Metrics**
Through new technology development and dissemination increase the size of the UDW resource base.	The 2000 MMS Assessment indicated that more than 50 billion recoverable BOE remains to be discovered. RPSEA's goal over the course of the Program is to develop the technologies required to help identify and discover 1% or more (1% is the equivalent of one 500 MMBOE or 5 100 MMBOE fields) of this potential. At current commodity prices this goal would be valued in excess of $30 billion. Achievement of this goal would mean over a 200:1 return on Program investment.
Convert currently identified (discovered) resources into economic recoverable (proven) reserves	The MMS 2006-022 Report identifies a gap of 9 BBOE between proven reserves and the discovered resource base. RPSEA goal is to add 100 MMBOE and more to the technically recoverable resource. At current commodity prices this goal would be valued in excess of $6 billion, roughly a more than 40:1 return on Program investment (additive to goal #1).

Table 2.1. Goals and Metrics for the UDW Program

UDW Program Objectives

Near term, by end of fiscal year 2008

Objective #1, Resource Analysis: Complete analytics to validate/calibrate MMS Assessment of remaining discoverable, recoverable resources. This task should be conducted by a third party under contract to RPSEA to ensure objectivity in results.

Objective #2, Technology Needs Assessment and Development: Complete the ongoing process to identify, prioritize, and develop the specific near term technologies that carry the greatest potential for adding to the UDW resource and reserve base.

Objective # 3, Cost Leverage: Work with academia, industry, capital markets and other key stakeholders to identify and capture cost-share funding and other incentives for leverage for prototype development of new analytical models and new enabling and enhancing technologies. A report will summarize accomplishments and document any recommendations

Intermediate-term Objectives, fiscal years 2010-2012

Objective #4, Technology Development and Deployment: Continue the development and maturation of the most promising technologies identified in the earlier phase with a strong focus on deployment and commercialization. Weed-out weaker prospects and focus budget and efforts on those that technologies that carry the greatest potential for adding to the UDW resource and reserve base. Project reports will be issued in a timely manner and will focus on end-to-end solutions that ensure all the necessary aspects to safely deploy in an environmental compliant fashion have been developed – or are being addressed.

Objective #5, Environment: Work with appropriate regulatory agencies, academia, industry and other key stakeholders to identify strategies to improve the industry's ability to measure and improve its environmental performance, then develop and execute appropriate projects / programs to achieve improvement. An analysis will be completed to establish a supportable baseline for program metrics to ensure measurable results.

Objective #6, Safety: Work with appropriate regulatory agencies and other key stakeholders to identify strategies to improve industry's safety record then develop and execute appropriate projects / programs to achieve improvement. An analysis will be completed to establish a supportable baseline for program metrics to ensure measurable results.

Long term Objectives to fiscal year 2015

In the final analysis to deliver on RPSEA's goal of increasing the size of the UDW resource base and converting that base to economically recoverable reserves, new planning and analytical models must be built; new equipment must be designed and manufactured; the equipment must then be demonstrated to be dependable and reliable, and ultimately manufactured and deployed in commercial quantities.

Objective #7, Demonstration: Work with industry, appropriate regulatory agencies and other key stakeholders to provide seed-level funding and other incentives for demonstration and validation of newly developed technologies. A baseline update research project will be carried out to ensure measurable results by 2015

Objective #8, Commercialization: Work with industry, appropriate regulatory agencies and other key stakeholders to provide seed-level funding and other incentives to ensure commercialization of emerging technologies.

Industry Barriers/Risks and Mitigation Strategies

Barriers have been identified for each of the goals discussed. RPSEA has developed and will adopt mitigating strategies to reduce overall risks and deliver the necessary technologies to commercialize this new resource base by:

- Properly identifying the most pressing needs
- Avoiding unproductive duplication
- Facilitating the development of industry standards & practices as appropriate
- Cost sharing of new technology development from basic research through demonstration and deployment
- Fostering timely and constructive communications across the value chain
- Creating enabling efficiencies among the stakeholders by facilitating collective rather than individual research which leverages participant's strengths and creates synergy, and minimizes the cost and risk versus such individual development

There are four pre-eminent risks to optimal program success:

- The highly competitive environment for qualified personnel and volunteers in the oil and gas industry
- Reduced levels of funding / high level of cost in associated with UDW
- Successful navigation through the "Valley of Death" (no cash flow)
- Coordination of the expectations of industry, academia, and government regarding program speed, direction and outcomes including proper alignment and management of intellectual property rights.

The RPSEA UDW Program provides an important forum that draws academia, industry, and regulators together to achieve objectives that result in synergistic, leveraged benefits.

- Operators provide the overall business guidance, conceptual systems architecture and deployment strategy of the "end user".
- Engineering, design firms, vendors and service organizations provide the products and services that make the systems possible.
- Regulatory agencies insure that drilling, production and other systems and operations are safe and adequately protect the environment.
- Universities, research institutions, and national laboratories provide innovation and early stage research capability.
- Federal agencies, such as the DOE ensure that the program conforms with national goals and serves the public interest consistent with EPACT and other related policies and statutes

The RPSEA UDW Program provides a tool or bridge that enables this cooperation to occur in a focused manner. It is well recognized that new technology will most likely not evolve as quickly outside of a jointly funded, cooperative effort such as the RPSEA UDW Program. Specific identified risks and proposed mitigation strategies are outlined below:

Risk #1. Limited Human Resources in the Oil and Gas Industry

There is significant competition for highly qualified personnel in the oil and gas sector consistent with nationwide concerns about the need for skilled workers, particularly in science and engineering disciplines. Implications of this risk for RPSEA are seen in two areas: staffing for the RPSEA organization itself; and assuring a pool of qualified individuals to participate in various RPSEA advisory committees.

Risk Management Strategy: RPSEA is leveraging the staff of existing organizations through subcontracts with key team members; through its subcontract with DeepStar via Chevron, RPSEA is tapping into a significant pool of world-class Subject Matter Experts (SME) already focused on similar technology challenges. *The value of these 700 plus SME volunteers, including academia, industry, and other key stakeholders serving on the various advisory committees is very significant; the value of the thousands of hours volunteer expertise, advice and counsel constitutes a substantial in-kind contribution to meeting the public policy objectives of RPSEA and the federal program it supports.*

RPSEA Communications and Technology Transfer Plans will provide tools and strategies for leveraging professional societies, trade associations, and academic and government research institutions, and others along the value chain thereby reducing the risk of "reinventing the wheel" and wasting valuable human capital.

Risk #2. Reduced funding level / high level of cost in associated with UDW

While the value to the American public of securing affordable UDW resources is significant, development and deployment of UDW technologies is an expensive proposition. EPACT funding is critical and must be effectively and efficiently leveraged.

Risk Management Strategy: RPSEA will place an intense focus on prioritizing high value-add projects, initially focusing on early successes and "low-hanging" fruit to address the public's interest in affordable, secure domestic supplies as soon as practicable. A strong focus on technology transfer within the industry and a broader focus on education will improve the potential for success. And as noted above, the monetary value of the in kind contribution in the form of domain expertise greatly reduces the administrative costs and federal funding requirements to conduct the program.

Risk #3. Successful Navigation Through the R&D "Valley of Death"

Any organization faces a substantial challenge in moving technology from the idea stage to technology adoption / commercial use. The segmentation of the natural gas and oil industry between producers, service companies, and universities/research organizations introduces additional challenges to the rapid adoption of new technologies. The industry is highly competitive and its core business is resource development. Profitability in the service segment of the industry has historically been insufficient to support breakthrough technology development and has tended to focus on incremental and specific shorter term market driven opportunities. Finally there is a general lack of information in the public policy domain and in the public in general about how the industry makes investment choices and decisions. Along the technology maturation curve between the early stage technology development (where public sector funding is generally limited to the academic institutions / national labs) and commercial deployment where cash flow funds operations lies the "Valley of Death".

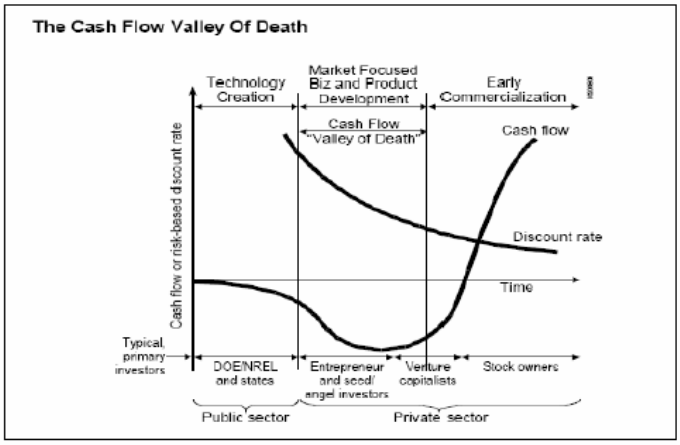


Figure 2.4; Cash Flow "Valley of Death". Normalized cash flow and risk adjusted discount rates as a function of business development stage, time, and the type of investors that are typically involved. L. M. Murphy; *National Renewable Energy Laboratory &* P. L. Edwards; *Altira Group LLC* Prepared under Task No. (7200.2050) NREL

Risk Management Strategy: To help bridge the gap that comprises the "Valley of Death", RPSEA will employ the following strategies presented at the Offshore Technology Conference special session on technology commercialization in 2004[2]:

- Secure long term stability and scale in funding of technology innovation and development
- Ensure that new, promising technologies are given testing opportunities, e.g. through explicit funds to technology manager to buy testing opportunities
  RPSEA's process requires an operator champion, strengthening potential for field test
- Negotiate and protect intellectual property consistent with federal requirements but with an understanding that rapid deployment of new technologies is ultimately in the public interest
- Ensure that technology and competence processes across assets are efficient – secure a "global" approach when appropriate.
  Many RPSEA members in the UDW arena operate in other deepwater basins.

[2] Offshore Technology Conference, 2004; Houston, Tx. OTC #16985;
Technology Commercialization; Trends and Strategies for Commercializing E&P Technologies;
Art J. Schroeder, Jr. Energy Valley, Inc ; comments courtesy of Mr. Joe Avila, McKinsey, Director, Energy & Technology Management Practices

- Use technology architects and internal "venture capital models" to run technology projects as a business
  RPSEA consortium membership and advisory groups represent all elements of the R&D value chain, increasing opportunities for success.

- Be open to share and receive ideas with others, avoid "not invented here" syndrome
  RPSEA will not own IPR and therefore will not compete with members.

- Actively explore alliances with small players
  RPSEA membership directly includes many small businesses and connects indirectly through member associations such as the non-profit Houston Technology Center

Risk #4. The Different Approaches of Government, Industry, and Academia

The government is interested in developing technologies that meet key public policy interests: secure and affordable, reliable and abundant energy supply, environmental protection and mitigation, and maximizing the value of federal resources. Public policy interests are sometimes in conflict with each other, are very complex, are subject to changing political environments, and are not always supported by commensurate policy and research investments.

Industry stakeholders tend to measure the value of research in the price and availability of a commodity. This places high value on short term results. Government policies and programs that are perceived by industry as "picking winners" could affect both the value of that commodity and the relative worth of the research beneficiaries; cost and price are critical measures of success.

Academia generally has a long range view of research, tempered by the competition for research dollars. The expertise of academics is invaluable but the academic environment is often inconsistent with the more immediate needs of industry and the demands of the marketplace. Academia has a crucial responsibility for training the next generation of technology practitioners without a clear mechanism for reliably funding that effort.

Risk Management Strategy: RPSEA UDW Program will have a project portfolio that consists of four core areas. The portfolio will reflect time scales and the technology maturation continuum from basic to applied research to demonstration to commercialization and will be organized around themes as described later in this section.

All projects awarded will address technology "needs" or "gaps" and will help RPSEA meet one or more of the goals set forth by EPACT; this will ensure that the interests of the government are met. The portfolio will have projects which focus on the short term (1-2 years), the medium term (2-5 years), and the long term (6-10 years). The portfolio will include a few, well funded projects at the top of the pyramid, although these projects may not be known in the initial planning year. There will be a larger number of research projects at the base of the pyramid, which will necessarily involve science themes and the academic community as the main source of innovation. These projects will generally be considered seed projects, some of which will grow into larger projects as warranted and with funding generally at lower amounts than those at the top of the pyramid. RPSEA recognizes that some projects will fail and that successful seed-level projects will require "follow-on" capital in order to reach the commercialization level of maturation.

As the Program matures, the strategy will naturally evolve to funding fewer projects that provide the best opportunity for developing technology that will make the highest contribution to achieving the goals set forth above in this document. Weaker projects will be terminated as the stronger projects take over more of the budget. Greater service company and operator involvement will be required at these stages of development.

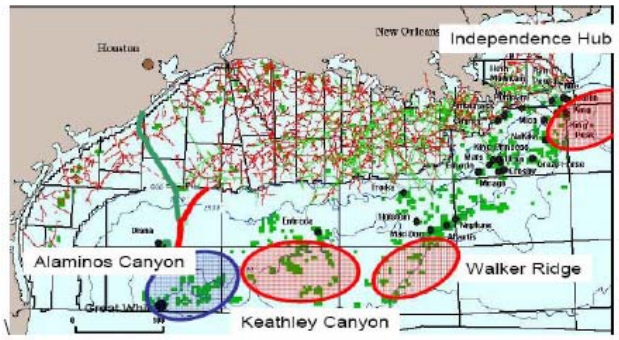
RPSEA provides the leadership, resources, and expertise to integrate the different needs, requirements, inputs, capabilities and objectives of these key stakeholder groups. RPSEA's BOD, President, staff, advisory committees, and membership have significant experience and expertise in the successful application of advanced technologies in the E&P industry. Their collective advice will provide RPSEA with the guidance necessary to successfully navigate the challenges that lay ahead.

Approach

As noted, RPSEA has subcontracted with DeeptStar through Chevron to assist it in managing the UDW program element; DeepStar is the world's largest UDW stakeholders group and has a 15 year history of managing collaborative research in the relevant domain. Through this arrangement, RPSEA has access to 700+ technical and management committee volunteers as well as a process of technology research, development, and commercialization. In addition to providing high level direction from the operators, who are ultimately responsible for the production of energy resources, this highly developed process strongly supports universities, regulatory bodies, and other key stake holder groups and formally facilitates their direct input. Through this process, over 50 universities, not-for-profit and other research institutes, and other organizations have received over $50M in research and technology development funds to extend the boundaries of deepwater from less than 3000 feet to nearly 10,000 feet. This process of broad engagement through expansive and inclusive TACs will be provide RPSEA with significant *pro bono* expertise as well as potentially significant matching funds to further accelerate the development of UDW.

From actual industry results in the UDW as identified in Figure 2.5 below, a systems engineering study was performed, and high-level design basis information was generated for the four base case scenarios identified. Additional detailed information will be developed and added to the system design basis as required by specific studies. Currently the design basis consists of the following information:

- 4 base case scenarios that illustrate the general arrangement of development facilities.
- Reservoir and well information for each base case.
- Flow Assurance Strategy for each base case.
- Met-ocean data using a typical GOM UDW location.



Walker Ridge / Keathley Canyon
- sub-salt
- deeper wells
- tight formations

Alaminos Canyon
- viscous crude
- lacking infrastructure

Eastern Gulf – Gas Independence Hub
- higher pressure & temperature
- CO2 / H2S

Overall
- higher drilling costs
- challenging economics

Figure 2.5 Technical challenges for identified basi

As part of the RPSEA Plan development process, and leveraging off this analysis, RPSEA UDW TACs utilized these four base cases listed below in Table 2.2 to generate technology themes.

Reservoir Trends	GOM BOE	Design Basis	Development Scenarios	Technology Themes
Canopy Field		Low permeability reservoir.	Semi with Wet Trees	
			FPSO with Wet Trees	
			FPSO EPS	
			Produce to Beach	
Gumout Field		High Viscosity Oil	Dry Tree Structure	
			Satellite Tieback to Host	
Coyote Field		Small Reserve Fields	Satellite Tieback to Host	
Diablo Field		XHPHT (22.5 ksi x 350+°F)	Semi w/ Gas Sweetening	
			Produce to Beach thru Sour Gas Pipeline	

Table 2.2 UDW Base Case Scenarios.
(BOE potential will be estimated as part of the initial benchmarking project and Technology Themes are presented in the "Prioritized Technology Needs" section)

Each base case reservoir trend has a design basis feature making some aspects of the development scenarios unique. It is the objective of the RPSEA UDW Program to identify and overcome the technical barriers identified by these design basis features. In several of these scenarios, near term technology is available and is pending field qualification. Such technologies will be matured, enabling or enhancing the viability of suitable deployment and demonstration opportunities. In addition to this input, considerable additional information was gathered from a number of diverse sources as listed in Table 2.3 below.

Event Type	Location	Date	Description
Roadmap session	Houston, Tx. (Tx. A&M & RPSEA)	Oct05	UDW Technology Roadmap Workshop; led by Tx. A&M, 100+ participants, 6 break-out sessions and final report
RPSEA Forums	Cambridge, MA. (MIT)	Oct06	Autonomous Intervention for Deepwater O&G Operations Forum
	Los Angeles, CA (USC)	Nov06	UDW Resources
	Houston, TX. (MIT & Chevron)	Jan07	Vortex Induced Vibrations Forum
	Tulsa, OK (University of Tulsa & Halliburton)	Feb07	Flow Assurance
RPSEA Advisory workshops	Houston, TX.	Oct06-Feb07	TACs numerous over this timeframe including hundreds of experts
Other	NPC study	Nov06	Draft Technical Section information
	RPSEA PAC & DeepStar Systems Engineering		Identification of Technology Needs study; 7902 report

Table 2.3. Input to the RPSEA UDW Program Plan

Committee Interaction

A general framework as described in Section 1 and also outlined in detail in Appendix B provides the program the means to identify, develop, and recommend solicitations which are aligned with the overall goals of the RPSEA UDW Program. It is intended to provide both technical guidance and a compliant process to support the decision-making process. The framework provides an overall philosophy that is used by the UDW PAC in the iterative process with the TACs to develop and communicate a plan that will help in achieving solutions to the technology themes identified by the broad and diverse membership of the TACs.

SMEs and asset owners linked together via a successful and time-tested DeepStar process provide the basis for the UDW Plan contained herein. The following section describes the interactions between the various committees in the development of this Plan.

Program Advisory Committee (PAC)

The RPSEA UDW PAC members represent asset owners that are currently operating in the UDW GOM. Their engagement in the process is critical as these operators will be the organizations called upon to actually deploy and operate the new technologies. The UDW PAC provides high level input on program priorities, field areas of interest, technology dissemination and a link to the producer and research communities, but its primary role is ultimate project selection. The current membership roster is included in Appendix A.

Technical Advisory Committee (TAC)

UDW field developments are extremely expensive and complex and require multi-discipline skill-sets to be coordinated to effectively, efficiently and safely produce the target reserves. The RPSEA UDW program is structured similarly to provide synergy between the technologies developed in this program and the engineers who will apply such technologies in real field developments. The technical discipline specialists are in the 9 TACs presented in Appendix A. The TACs identify the technology gaps and eventually define specific projects to address these gaps. As such, the TACs provide a bottom-up end user driven program as the originators of the technology themes, highlighting the importance and role of the TACs and their diverse constituencies. RPSEA members are encouraged and invited to express their particular technical interests and then to participate in the respective TAC meetings and processes.

The UDW program has been defined in a collection of "themes" or issues associated with the 4 base case field development scenarios presented in Table 2.2 above. The SMEs in the TACs are challenged to define specific project plans in terms of costs, time and resources to address the critical aspects of the various themes, which will serve as the basis for solicitations.

Prioritized Technology Needs

The previous description and material provided thus far in Section 2 have provided a framework for general research needs in the UDW. This section refines those needs into the current Annual Plan. The 4 base case scenarios developed for the UDW Program were reviewed by the nine (9) UDW TACs and each TAC has identified the highest priority "Themes" for their respective disciplines. The following Technology Themes were identified by the SMEs in the 9 TACs. The committees identified the areas of study (themes) that apply to the four base case field development scenarios previously discussed.

The TACs when focused on the four base cases, identified a number of themes which are multi-disciplinary or cross-cut several TACs. RPSEA will coordinate these cross-cuts/multi-disciplinary areas at the CEO staff level, who will then assist the PAC in providing integrated and prioritized recommendations in this regard. The systems nature of the UDW program, its complexity and the overall systems/architecture focus of the UDW program as articulated in EPACT drives the numerous themes for PAC prioritization relative to the other two program elements.

Drilling and Completion Themes

The Drilling and Completions TAC is responsible for construction, completion and maintenance of the well. This discipline represents the largest area of capital expenditures (CAPEX) in UDW field development. Improvements impacting the efficiency of these operations will be significant to bring resources on line.

Drilling and Completion Themes organized by Base case field include:

Canopy Field (Subsalt low Permeability Reservoir)

- Completion of long reservoir sections
- Deep reservoir stimulation technology

- Formation Integrity at Commercial Production Conditions (fluid rates, differential pressures.)

Coyote Field (low energy reservoir with small reserves)

- Drilling with small margin between overburden and fracture pressure (dual density drilling is a potential solution for this issue).

Gumout Field (Viscous Crude)

- Intervention strategies and well architecture for downhole equipment maintenance (pumps for example)

Diablo Field (HPHT)

- Material for all tubulars
- All consumable products
- All tools and instrumentation
- All Completion equipment

Environmental, Safety & Regulatory Themes

Offshore operators are required by MMS to gain approval for new technology before submitting development and operation plans that incorporate the new technology into the operator's activities in federal waters. The approvals are part of the review process that's required for lease operations in deepwater GOM, in water depths greater than 1000 feet. Through the approval process, MMS verifies that the new systems are technically sound and safe. Reviewed by MMS petroleum and structural engineers, the new technology is approved for use only after hazard analyses are conducted. The engineers consider the many different conditions that can exist offshore and also confirm that there is a proven method to shut-down operations in the case of a failure. This approval process incorporates two overriding goals of MMS: to increase the safety of the people doing the work and to protect the ocean environment.

The Environmental, Safety and Regulatory TAC serves as a liaison between the other RPSEA UDW Program technical committees and governmental regulators for the U.S. GOM, such as the Minerals Management Services, the US Coast Guard (USCG), and the Environmental Protection Agency - EPA. The TAC's role is to facilitate an exchange of technical information between the working technical groups in RPSEA UDW Program and regulatory representatives. The committee also works and communicates with leading industry organizations, such as the Offshore Operators Committee (OOC), American Petroleum Institute (API), and others. As new technical issues surface and new technology proposed for offshore deployment, this committee will coordinate regulatory concerns and issues. Such interaction provides guidance to the technology developers and allows regulatory issues to be addressed appropriately in a timely manner. Further, there are some standards (like environmental and performance tests) which may require technology solutions; this committee will identify appropriate solutions to address these issues.

Identified themes include:

Safety Barrier Testing and Validation Criteria

Environmental and Regulatory Impact of Emerging Technologies

UDW Produced Water Management
This includes measurement, monitoring of oil in water (OIW), disposal and energy conservation through the elimination of lifting the water to the surface for treatment. Cost savings resulting from not having large water treatment facilities on floating structures. It would be best if the water could be maintained in the formation.

Floating Facilities Themes

Unlike the other committees, technology requirements for the Floating Systems TAC are not tied directly to the field development scenarios and could be applied to all of the scenarios. The one exception is riser requirements for the Diablo field which require understanding of materials and riser designs for the extreme high temperature, high pressure (XHPHT), and sour service conditions. Most hull and mooring technologies are considered to be "enhancing" technologies to improve development economics or reliability of installed systems.

To address issues of reliability, economics and XHPHT sour service, the committee has defined the following themes:

a. Optimized UDW Field Development Concepts for Improved Economics
b. Materials Sciences for UDW Risers and Moorings
c. Improved Design and Analysis Methods
d. Mooring and Riser Integrity Management

A summary of these themes follows.

Optimized UDW Field Development Concepts for Improved Economics

Alternative and optimized floating system concepts (including associated risers and moorings) can greatly improve development economics. The concepts having the most direct impact to the DeepStar field development scenarios include:

- Early Production System (EPS) or extended well test systems and associated moorings and risers (Coyote field). These must have characteristics of low Capital Expenditure (CAPEX), short execution schedule and be easily relocated. The most likely candidate hull is the Floating, Processing, Storage and Offloading Facility (FPSO) (either moored or Dynamically Positioned - DP) but could also be a semisubmersible or other hull form. Riser designs for the EPS need to be progressed, especially those for the high motions of the FPSO or for UDW.
- Hull and riser designs for direct well access to reduce maintenance costs, especially for fields requiring frequent workovers (Canopy field, Gumout field, Coyote field). This would include Spars and Tension Leg Platforms (TLPs) and associated risers and moorings. Progressing a dry-tree semisubmersible would provide an alternative to the spar for dry-tree production units.

- For UDW systems, riser weight management is a major issue. Except for riser towers, which decouple the riser load from the floater, the riser loads have a direct impact on size of the floating system and hence cost. The problem becomes worse for HPHT systems requiring heavy walled risers (Coyote field, Diablo field).

Materials Science for Risers and Moorings

Materials science can be categorized as either a better understanding of existing materials used in hull, mooring and riser systems or as the use of new materials to improve performance, reduce weight or to improve fatigue for sour service. The topics listed here would apply to any of the field development scenarios except for the extra corrosive environment represented by the Diablo field:

- Riser fatigue capacity: Riser fatigue capacity has been addressed for specific issues in a variety of research forums. An understanding of the current state of the art is required to ensure that gaps are being filled and to reduce conservatism in design.
- Alternative materials to address performance (weight, floater offsets, fatigue, etc) issues are needed for moorings and risers. To extend the water depth capabilities, reduce payload, or reduce offsets research is needed into synthetic materials for moorings. This also includes composites for TLP tendons. One specific area of concern is the Diablo field case requiring risers for XHPHT, sour service in UDW. This case may also require research into alternative materials and their associated fatigue capacities.

Improved Design/Analyses Methods

Much of the work done already done through DeepStar and other Joint Industry Projects (JIPs) has been in the area of design and analysis techniques and has pointed to several shortcomings in the industry's capabilities. Some areas that have been highlighted as needing additional research include:

- Riser Vortex Induced Vibration (VIV) and hull Vortex Induced Motion (VIM) prediction and mitigation and associated effect on fatigue of mooring and riser components. Data is needed from model scale and full-scale tests to calibrate and improve current predictive techniques including empirical VIV tools and Computational Fluid Dynamics (CFD). This improved understanding and prediction capability along with research into suppression techniques and effectiveness may lead to reduced cost VIV/VIM suppression options.
- Miscellaneous design/analysis issues that require additional study to reduce conservatism in design include Steel Catenary Riser (SCR) touchdown point modeling, riser array dynamics, and wave impact loading.

Mooring and Riser Integrity Management

Current designs are expected to be conservative. However, the industry is designing for conditions outside of the design experience (e.g., XHPHT, UDW, high currents, etc.). Failures in recent years have highlighted the need for improved monitoring and inspection with feedback for better prediction of remaining life of components. These include the following:

- Mooring and riser integrity management systems consisting of monitoring, inspection and prediction of remaining life of components.
- Validation of floating system global analysis techniques and model testing. For UDW systems, improved model testing techniques are required to overcome the water depth limitations of testing facilities.
- Calibration of design tools for global analysis and analysis of moorings and risers using full-scale measured data.

Flow Assurance Themes

The Flow Assurance (FA) TAC is responsible for movement of production from the bottom of the well as it moves to the surface, through the production system, process system and to the point of market or disposal.

The FA TAC working group developed the following themes for the four base case development scenarios. Input to the TAC working group was received from various sources including a Workshop held at Tulsa University. The major themes are:

HPHT Flow Assurance Technology. There are many FA unknowns and testing will be required to develop answers. This includes: Equation of State viability for XHPHT conditions; Effectiveness of production chemistry; cold spot criticality analysis, etc…..

Viscous Oil Production Technology. This includes:

- Multiphase flow issues
- Artificial lift
- Modeling guidelines for viscous oils
- Viscosity reduction and management. This is a multidiscipline effort with the reservoir committee to maximize reservoir recovery. It also includes evaluating some novel conceptual ideas for their potential to improve the ultimate reservoir recovery factor.

Organic, Inorganic and Solids Management covers all forms of deposition occurring in the production system (waxes, asphaltenes, hydrates, scales, etc.). It includes all forms of solids (sand, scale, etc) transported in the production and evaluating their impact on the production system (erosion).

Geo-science Themes

The UDW part of the GOM poses many Geological and Geophysical (G & G) challenges to the exploitation of hydrocarbons. Many of these challenges are related to a combination of the UDW environment and the presence of a regionally extensive thick salt canopy which overlies the prospective subsalt section. The combination of a deep water column and thick salt layer pose a formidable challenge for acquiring data and accessing resources. The environmental conditions and costs associated with the UDW setting and deep reservoirs also impact the type and amount of geological and geophysical data that can be gathered. High drilling costs result in expensive exploration wells, sparse appraisal wells, limited sampling/ production testing and

development decisions based on very limited data. The challenges cross beyond G & G into drilling and include cost reduction, risk reduction, improved resource identification and improved recovery per well. EPACT has established a mechanism that will facilitate a partnership of government and industry to research, develop and optimize techniques, technologies and tools that enable us to overcome the geosciences challenges described below:

Challenges

a. **Subsalt Imaging** - The challenge of imaging the subsalt section is formidable. Complex structural and sedimentary geometries impact our ability to image and understand the classic elements of trap, reservoir source and seal under the salt canopy. Significant improvements in subsalt image quality, reliability and resolution are required.

b. **Reservoir Characterization** - Poor imaging and sparse data challenge our ability to understand depositional systems, predict reservoir distribution & reservoir heterogeneity, quantify reservoir compaction and undertake reservoir monitoring.

c. **Fluid Characterization** - Limited subsalt production, testing & sampling challenges our ability to predict fluid composition and characteristics and understand reservoir geochemistry

d. **Economics** - Expensive operations and limited resources challenge the size, type and number of opportunities that can be drilled and evaluated.

e. **High Pressure, High Temperature** - Deeper objectives result in more hostile downhole conditions. HPHT settings challenge us to be able to drill, evaluate and sample/ test with conventional equipment and techniques

f. **Geo-mechanics** - The UDW environment can impact drilling and facilities operations, it presents several geo-mechanical challenges that can increase the risk and cost of a project e.g. drilling hazards, subsidence & wellbore integrity.

Having established the key challenges facing G & G in UDW, it is necessary to discuss the objectives of the R & D. They are to optimize existing technology or operations; stimulate the development and demonstration of new technology & equipment; support the development of enabling technologies; encourage longer term and blue skies R & D. It is accepted that Geo-science R & D is a sensitive issue. RPSEA will at all times seek to avoid infringing on commercially competitive areas in its management of this research theme.

Geo-science Sub-Themes:

a. **Subsalt Imaging & Geo-mechanics** – Increased azimuth 3D seismic, seismic cquisition geometry modeling, illumination studies, velocity modeling, 3D time and depth processing, ocean bottom multi-component seismic, interpretations tools, eismicinversion, 4D seismic, wellbore seismic, potential methods, combination methods and associated topics such as high performance computing, neural nets etc. The Geo-mechanic issues include: Geo-mechanical studies, drilling hazard prediction, subsidence and sea floor stability, wellbore stability, sand control, fracturing.

b. **Reservoir and Fluid Characterization** – Reservoir architecture, formation evaluation, rock properties, reservoir porosity and permeability prediction, modeling and simulation, reservoir compaction, reservoir surveillance and monitoring, reservoir performance prediction and production matching and associated topics such as modeling, visualization, real time monitoring systems, uncertainty analysis and decision making. Similarly; Fluid Characterization includes: **–** fluid properties**,** reservoir geochemistry & aquifer composition, basin modeling & reconstruction, fluid type & gravity prediction w/o drilling, source rock sampling, seep analysis.

c. **High Pressure, High Temperature** – HPHT formation evaluation tools, sampling, testing and deliverability, production and reserves assessment, deeply buried reservoir studies.

d. **Economics –** (In partnership with 8500 drilling committee) slimhole drilling, microhole drilling project, coiled tubing drilling, finder well concept, badger and mole drilling.

The specific work scopes for each of these themes will be presented in CTRs (Cost, Time & Resource Plan) developed and prioritized by the TACs.

Met-Ocean Themes

Met-Ocean is an acronym for "meteorology and oceanography". The discipline entails quantifying the marine environment in which the offshore industry must operate, i.e. specifying the climatology of winds, waves, currents, water temperature, etc., as well as determining their likely extremes.

While normal conditions in the GOM can be deceptively calm, the Gulf can experience some of the largest waves and currents observed anywhere in the world. For instance, during Hurricane Ivan, waves of at least 100 feet height were recorded. Beneath the ocean surface, the Loop Current and its associated eddies (Loop/eddies) can generate currents well in excess of 4 kn. In short, the met-ocean environment in the deepwater Gulf presents numerous challenges that fundamentally affect the design and operation of all our offshore activities.

While the Industry has been active in investigating deepwater met-ocean issues, there remains much to be quantified and learned because deep water met-ocean phenomena have proven to be complex and poorly documented. Key met-ocean themes include:

Investigating the role of changing weather patterns on hurricane severity. Several recent papers have demonstrated that hurricanes are increasing in severity because of changing weather patterns. This debate has been monitored but significant research needs to be done to determine its impact on operations and to assess mitigation options.

Setting-up an operational 3-D current forecast model capable of simulating the Loop/eddies. This effort would be a cooperative effort that would leverage funds from NOAA and possibly other government agencies.

Taking measurements and refining a model of strong near-bottom currents along the Sigsbee Escarpment. Limited measurements have shown that these currents are an important factor in design. Additional work is needed to refine existing models to predict how the currents vary by location, and to develop forecast capability.

Reservoir Themes

The reservoir committee has focused on the challenges that exist in the different phases of a reservoir's life. While this general theme has competitive sensitivities similar to the Geo-science theme, opportunities to achieve non-competitive impact exist in each phase. The technology needs have been segregated into these phases (or "themes") and sample work has been identified. Direct links to the base case field developments where such work programs will add value have been included. The TAC will refine these technology needs and work suggestions into a recommended Reservoir TAC program.

Appraisal

Long-term Goal – delineation of the reservoir including fluid and rock properties, internal architecture and continuity, and drive mechanism for full field development planning without additional drilling and additional time for reservoir characterization.

Strategy – build to the ultimate goal through a series of steps from prediction in absence of data to obtaining more reliable data, which ultimately reduces the need and number of appraisal wells. In addition, reduction of cycle time or the time needed to understand the data will improve the economics by bringing fields on production sooner after discovery.

- Prediction in absence of good data
- Analog databases
- Advance current technology to improve data quality
- Improve formation evaluation techniques including well testing and fluid sampling while drilling and low cost interference testing.
- Improve the reliability for predicting: non-commercial zones, and reservoir connectivity
- Maximize data from a well
  Downhole instrumentation for reservoir description
  Abandon well with instrumentation
- Reduce cycle time for appraisal
- Development of commercially economic early production systems

Field Development

Long-term goal – build and implement field and reservoir development plans that are flexible enough to meet changing physical conditions and maintain economic robustness (under changing fiscal climates) down to reservoir size of 1 barrel of original oil in place.

Strategy – obtainment of the ultimate goal requires short term goals of good prediction of the production of the reservoir and of changes occurring in the reservoir. Economic robustness of marginally small fields and UDW requires low well count; therefore, wells must perform better in terms of rate and recovery.

- Prediction of reservoir production and changes
  - Reservoir compaction
  - Reservoir souring prediction and prevention *Canopy*
  - Stress changes in salt *Canopy*

- Multi-discipline modeling and other tools
  - Fully integrated visualization tools
  - Fully integrated modeling from reservoir to sales line

- Improve recoveries through wells
  - Higher rate wells for longer terms *Canopy*
  - Higher recoveries per well *Canopy*
  - Improve sand control
  - Improve artificial lift *Canopy*
  - Wells and completions capable of high drawdowns and flux rate *Canopy*
  - Improve well productivity *Canopy*
  - Improve well reliability through reservoir management
  - Database of completion and stimulation results *Canopy*
  - Gas condensate well performance prediction and models *Diablo*
  - Horizontal and multilateral well performance prediction *Canopy*
  - Use of intelligent well technology

- New ideas/blue sky research to make step change in technology
  - Improve UDW developments by breaking paradigm of increasing costs with water depth *Perdido Fold Belt*

- Economic development of low permeability reservoirs in deepwater *Canopy*

Production and Reservoir Surveillance

Long-term goal – produce the reservoirs to zero residual hydrocarbons with zero operating expenses.

Strategy – study methods that will reduce the amount of remaining hydrocarbons at abandonment (economic limit) by reducing the amount of bypassed and residual hydrocarbons. The abandonment conditions are dictated by the economic cash flow, and therefore, the reduction of operating expenses will ultimately increase oil recovery.

a. Reduce bypass reserves

- Fast detection of pressure support from flood or aquifer
- Improve passive and 4D seismic for pressure and fluid saturation changes and incorporation to reservoir description
- Monitor commingled completions

- Injection fluid conformance control *Canopy*
- Formation evaluation from continuous pressure data and tracer applications

b. Reduce operating expenses

- Develop completions requiring no interventions
- Flow assurance mitigation and transient modeling
  Produce water management and improved water production shutoff

c. Reduce residual hydrocarbons

- Enhanced oil recovery (EOR) *Canopy*
- Other injected fluids besides water
- Mixed injection fluids

Although benefits can be obtained through extending current research areas, some attention should be directed towards new approaches and ideas – a step change in technology is requried. Sessions of blue sky brainstorm with the directive to break traditional paradigms should be conducted to impact all phases of the development of hydrocarbon fields. New holistic, multidiscipline approaches may lead to game changing solutions.

Subsea Facilities Themes

The Subsea Facilities includes all equipment above the wellhead to the production risers. This may include trees, controls, pumps, separation, manifolding, chemical system, intervention equipment and all related installation and maintenance tools.

Subsea Production Equipment Enhancements significantly improve existing technology to make it safer, more reliable and easier/less costly to maintain. Some enhancement examples include:

- Subsea electric actuators and controls on valves and other subsea equipment
- Insulated and Un-insulated Xmas Tree arrangements (for effective hydrate management)
- Validate and demonstrate that hydrostatic pressure may be used in determining the effective pressure rating of subsea production equipment per API 17D.
- XHPHT rated equipment designs and qualification processes.

Mature Subsea Processing Technology. This includes pumping, compression, separation, water disposal, metering, chemical injection, power distribution, controls, sensors and HIPPs. Such system working together or separately may be configured to

enable extreme offset production facilities by stabilizing the production before its transportation to the beach.

Pipeline, Flowline and Umbilical Technology Improvement. The bathometry in the base case areas are similar to the hill country, which makes pipelines in these areas challenging to construct and operate. The following themes address these issues:

- Installation and intervention technology in deepwater
- Insulation methods for deepwater pipelines (including high temperature lines).
- Instrumentation for integrity management of pipelines, flowlines and umbilicals.
- Novel materials and physical arrangements.

Subsea Well Intervention Technology improvement. This includes in-water services (remote operated vehicles (ROV) and autonomous underwater vehicles (AUV) with tooling). It also includes most equipment /intervention service interfaces.

Systems Engineering and Architecture Themes

System Engineering evaluates system level activities and coordinates between the various discipline specialists working on their respective themes. The Committee also sponsors emerging technology evaluations, Challenge Projects, and other step-change innovation to improve field economics and safe operations. The following themes provide for these services.

Develop and maintain **Design Criteria for the Base Cases**. This will be done in conjunction with the other TACs SMEs. Further work provides coordination between the various TACs to ensure integrated solutions result from the various committee activities as many projects are multi-discipline efforts..

Evaluate the **system impact of proposed technologies on the field development scenarios**. This information will aid the PAC in funding decisions and direction of further study. Further this activity will provide economic information documenting the value of sponsored work.

Manage Deepwater **Grand Challenge projects**. This is a seed money effort to evaluate new concepts or out-of-the-box solutions. This potentially may lead to "break-through" or game changing solutions. Possible grand challenges may include:

- Develop the ability to drill or "robotically tunnel" 20 miles horizontally to access a reservoir. Spin-off opportunities may include construction tunneling from replacing aging infrastructure, etc. It reduces environmental impact by allowing for drill centers to develop a larger surrounding region.
- Develop a complete sea-floor based drilling rig. Such systems may represent a significant change in deepwater drilling costs. If developed, such system may have future potential in Arctic regions working under the ice pack.
- Further develop the application of composite products subsea. This will reduce weight and may enable the use of lower cost support vessels to perform work

traditionally accomplished by more expensive vessels today. For example. A composite buoyant flowline could be intermittently tethered to the ocean floor (at approximately 1 km spacing). The 1 km spacing would enable such flowlines to be used in areas with rough bathymetry. For example, the flowline could span a slot canyon or jump over a subsea escarpment.

- Other possible "Grand Challenges" may be added to this list.

Small Business Initiatives. This theme will maintain "Seed Money" allowing small businesses to develop the added value of their emerging products. RPSEA will engage various organizations (like the Houston Technology Center) for assistance in identifying emerging technologies with interesting potential for the UDW Program.

Summary

A total of 32 themes have been identified though the RPSEA UDW process and are summarized in Table 2.4 below. Not all themes may be worked in the first (or second) year. Each theme will be further developed into prioritized RFPs. It is anticipated that the UDW program, in the intial year, will recommend 10-30 projects ranging from $250K to $3 MM having an average RPSEA contribution of $750K.

	TACs	Themes
	Drilling & Completion	
1		Canopy Field (Subsalt low Permeability Reservoir)
2		Coyote Field (low energy reservoir w/ small reserves).
3		Gumout Field (Viscous Crude)
4		Diablo Field (HPHT)
	Environmental, Safety & Regulatory Themes	
5		Safety Barrier Testing and Validation Criteria
6		Environmental and Regulatory Impact of Emerging Technologies
7		Deepwater Produced Water Management
	Floating Facilities Themes	
8		Optimized UDW Field Development Concepts for Improved Economics
9		Materials Sciences for UDW Risers and Moorings
10		Improved Design and Analysis Methods
11		Mooring and Riser Integrity Management
	Flow Assurance Themes	
12		HPHT Flow Assurance Technology.
13		Viscous Oil Production Technology
14		Organic, Inorganic and Solids Management
	Geo-science Themes	
15		Subsalt Imaging & Geo-mechanics
16		Reservoir and Fluid Characterization –
17		High Pressure, High Temperature
18		Economics
	Met-ocean	
19		Investigating the role of changing weather patterns on hurricane severity.

	TACs	Themes
20		Setting-up an operational 3-D current forecast model capable of simulating the Loop/eddies.
21		Taking measurements and refining a model of strong near-bottom currents along the Sigsbee Escarpment.
	Reservoir Themes	
22		Appraisal Theme
23		Field development
24		Production and Reservoir Surveillance
	Subsea Facilities Themes	
25		Subsea Production Equipment Enhancements
26		Mature Subsea Processing Technology
27		Pipeline, Flowline and Umbilical Technology
28		Subsea Well Intervention Technology improvement
	Systems Engineering and Architecture	
29		Design Criteria for the Base Cases.
30		System impact of proposed technologies on the field development scenarios.
31		Grand Challenge projects
32		Small Business Initiatives

Table 2. 4 UDW Program Themes

Coordination with Complementary NETL Program

With RPSEA's extensive UDW advisory committee organization, much if not most of the current work on UDW technologies will be known and factored into the UDW Program, thus minimizing potential duplication of technical development efforts by the NETL complementary program. The UDW TACs have already identified a number of "UDW themes" from which NETL may elect to perform projects which particularly match their capabilities and expertise.

Planned solicitations

The identified four (4) reservoir trends (discussed in earlier section) represent in a generic sense the majority of the anticipated UDW resources. Technical challenges associated with these trends give rise to 32 themes. From the themes, SMEs on the various TACs with guidance from the UDW PAC, other RPSEA groups, and NETL will develop solicitations to call on the nation's research universities, national labs, industry and others to generate proposals targeted to addressing and solving the many challenges facing operators in the UDW GOM. A general overview of the entire RPSEA solicitation process is included in Appendix B. Solicitations will reflect the desire to establish a balanced research portfolio to reflect an appropriate mix of science, enabling, enhancing and "Grand Challenge" projects.

Section 3

UNCONVENTIONAL NATURAL GAS & OTHER PETROLEUM RESOURCES PROGRAM ELEMENT

A. Unconventional Natural Gas and Other Petroleum Resources Mission

The mission of the unconventional natural gas and other petroleum resources program element is to increase the supply of domestic natural gas and other petroleum resources through reducing the cost and increasing the efficiency of exploration for and production of such resources, while improving safety and minimizing environmental impact.

"Unconventional natural gas and other petroleum resource" is defined in EPACT as natural gas and other petroleum resource located onshore in an economically inaccessible geological formation, including the resources of small producers.

B. Resource Opportunities and Priorities

Unconventional natural gas resources are best described as those gas accumulations that are hard to characterize and commercially produce by common exploration and production technologies. These resources are typically located in heterogeneous, extremely complex, and often poorly understood geologic systems, often easy to find but difficult to produce. For example, while it is not difficult to find large lenticular sand packages in many basins it is very difficult to determine their flow properties from petrophysical well surveys and to design effective completion procedures. Furthermore, because of their very low permeability, establishing gas flow at a reasonable commercial rate requires costly production stimulation operations. These types of considerations are responsible for the high risk factors and unpredictable results often associated with unconventional gas exploration and development projects that inhibit industry investment in these resources.

The largest volume of unconventional gas in the United States occurs in three specific resources - tight sands, gas shales, and coalbed methane. These three resources occur in numerous geologic basins all across the lower 48 States. According to the latest estimate by the National Petroleum Council (NPC 2003) the volume of technically recoverable gas from these three resources is in excess of 293 trillion cubic feet (TCF). Total natural gas resources are broadly depicted in Figure 3.1.

In addition to being more accessible and having the potential of attracting serious industry participation, these three resources often occur at shallower depths under moderate to low pressure and temperature conditions. Thus, their exploitation may not hinge upon the development of the new materials and technologies that would have to be developed for handling the hostile environments prevailing in other unconventional environments.

The funding available for the Unconventional Resources program element is not sufficient to address all types of unconventional resources and have a measurable impact in a time frame of a few years. As it is desirable for the program to show some initial results in this short time frame, a substantial amount of the early R&D investment will be directed toward gas shales, tight sands and coalbed methane. However, this prioritization does not preclude research and development on other unconventional resources such as deep onshore gas, complex carbonate reservoirs and basin-centered gas, particularly during the latter years of the program plan and/or in pursuit of research and development aimed at development of longer term objectives.

A brief description of tight sands, gas shales, and coalbed methane resources is given in Appendix C, highlighting the size of the resource and some of the unique challenges associated with each resource type.

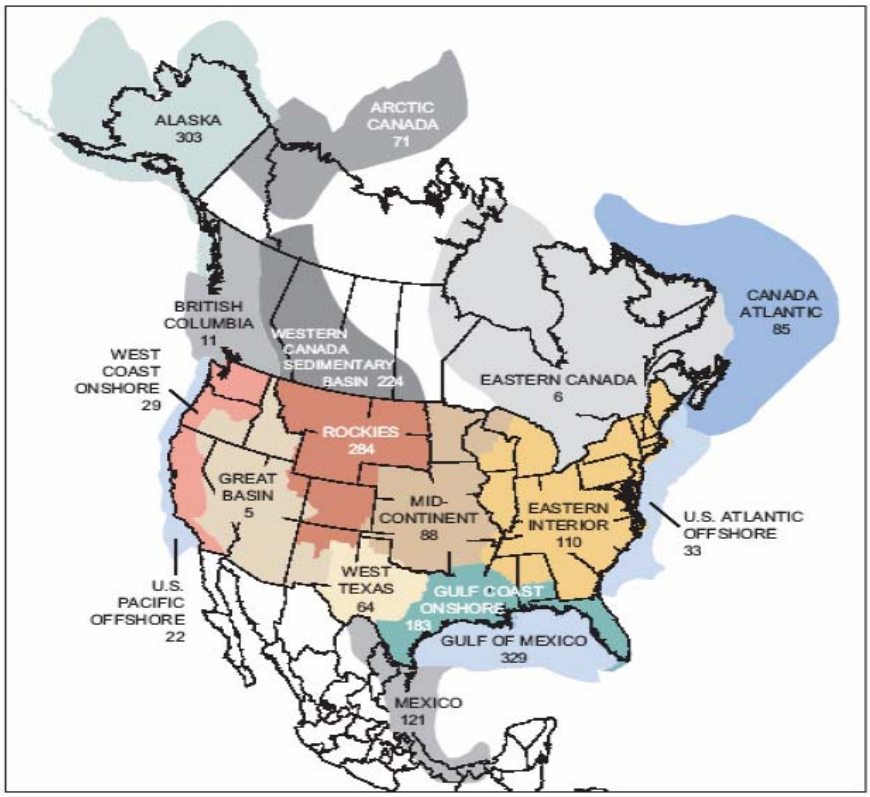


Figure 3.1 NPC Technically Recoverable Resources, TCF (NPC, 2003)

C. *Unconventional Program Goals and Metrics*

The primary goal of the RPSEA Unconventional Onshore Resources Program is to increase the supply of natural gas from unconventional resources while improving safety and minimizing environmental impacts, thus providing the U.S. gas consumer with a secure and affordable natural gas supply. Four strategic goals have been established to guide program implementation. The four goals are stated in Table 3.1 followed by discussion of each goal, with specific objectives, barriers and overall strategy to meet the goal.

Unconventional Gas Program Strategic Goals
Goal #1: Through new technology development and dissemination increase the size of the technically recoverable unconventional gas resource base.
Goal #2: Convert through a focused research program technically recoverable unconventional gas resource to economically recoverable gas that can be harvested in an environmentally sound manner.
Goal #3: Develop technologies for improving unconventional resource recovery with minimum environmental impact.
Goal #4: Develop the R&D Program's science building capacity; Develop significant industry support and participation; and Develop a Program with a strong and successful technology dissemination component.
Program Metrics
Metric #1: Increase the Technically Recoverable Unconventional Gas Resource base by 30 TCF.
Metric #2: Convert 10 TCF of Technically Recoverable Unconventional Gas Resource to Economic Reserves.

Table 3.1 Unconventional Gas Program Strategic Goals and Metrics

Each TCF of unconventional gas added to the economic reserve base has a direct economic value of $8 billion at today's prices. If the program goal of 10 TCF is reached, the value of additional economic reserves will be $80 billion. While considerable investment will be required to produce these reserves, the value to the U.S. consumer of access to this secure and affordable source of clean energy is clearly put in perspective relative to the $150 million R&D investment over the ten year span of the Unconventional Resource program, not including the indirect non-economic benefits of this domestic and clean burning energy source.

The following discussion establishes quantitative metrics for each goal, states objectives and identifies barriers to meeting the goal. This is followed by strategy components for each goal addressing in particular how to overcome barriers.

Goal 1: Increase Resource Base

Through new technology development and dissemination increase the size of the technically recoverable unconventional gas resource base.

Metric:

The NPC 2003 technically recoverable unconventional resource base is currently 293 TCF. This number, as with the overall resource base, has grown in magnitude in past years due to new technology applications. A goal of the program is to add 30 TCF to the technically recoverable unconventional resource.

Objective:

- By 2008 identify the three emerging or existing geologic areas/basins that carry the greatest potential for adding to the technically recoverable resource base.
- By 2008, complete resource potential assessments and area prioritization.
- By 2011, conclude field based research programs in each of the three prospective areas documenting growth potential. Accurate measurements of field data such as production and reserves as well as reservoir data such as porosity, permeability, and gas content will be collected, ultimately supporting an increase in the technically recoverable resource base.
- Disseminate the results through seminars and producer workshops (ongoing throughout the research) increasing the understanding of these resource areas to the extent producer activity (drilling) takes place,

Barriers:

- Lack of funding for research programs in recent years has precluded the level of effort necessary to address important resource issues. In particular, funding for expensive field based activities necessary for required technology advancement has been lacking.
- This is the domain of the independent producer who is without the staff, time, research expertise, and financial resources to efficiently develop and adopt new technology. Oil and gas development is increasingly more complex and technical solutions useable by independents more challenging.
- Increasing the technically recoverable resource base requires the resource be assessed in an integrated manner. Reservoir characterization must be coupled with formation evaluation which must be integrated with extraction strategies (horizontal wells, microholes, etc.) along with all environmental issues.

Strategies:

- Focus the Program – Prioritize to three geologic areas/basins to achieve impact. There are numerous geologic basins and plays all deserving of research programs. Prioritization will identify those with the greatest potential allowing selection of three priority areas.
- Work with industry – Producer community involvement throughout the program, from the early stages of planning through field testing, is essential to assure a relevant program. Independent producers have specific and unique needs. Their "hands on" involvement is necessary for impact.
- Plan a comprehensive program including all aspects required to accomplish the goal. Geology, geophysics, formation evaluation, drilling, completion, environmental and other disciplines need to be adequately addressed in an integrated fashion.
- Conduct ongoing planning and assessment. The ability to achieve results must be constantly monitored and assessed with respect to available resources. If experimental needs within the program relative to resources (funding) dictate further prioritization be implemented, e.g. limiting focus from three areas down to one area, this must be accomplished.

Goal 2: Recover Reserves

Convert through a focused research program technically recoverable unconventional gas resource to economically recoverable gas resource that can be harvested in an environmentally sound manner.

Metric:

The technically recoverable unconventional resource base is currently 293 TCF. None of this resource is currently economic, but can be made so through the development and application of new technology that drives down the cost and environmental impact of development of this reserve base. A goal of this program is to convert 10 TCF of unconventional gas resource from technically recoverable to economic. It should be noted that Goal #2 and #1 are closely related in how they will be achieved.

Objective:

By 2008, identify the three geologic areas/basins with gas shales, tight sands and/or CBM resources that carry the greatest potential for adding to the economic resource base.

- By 2007, through planning activities with advisors and producers identify geologic plays with the greatest potential for research program impact.
- By 2008, initiate field based research programs in each of the prospective areas.
- By 2009, complete the initial field testing and modify the program based on results. This could result in selecting and moving to a new area, consolidating the entire program in one area or some other combination.
- Disseminate the program results through appropriate venues, determine the program impact and make adjustments as required.

Barriers:

- Lack of funding for research programs in recent years has precluded the level of effort necessary to address the resource issues. A particular issue has been the absence of funding support for expensive field based activities necessary for research progress.
- As with Goal #1 above, this is the domain of the independent producer who is without the staff, time research expertise, and financial resources to develop and adopt new technology. Oil and gas development is increasing in complexity and technical solutions useable by independents are necessary.
- Maximizing additions to the resource base in addition to converting technical resource to economic resource (i.e., accomplishing both Goal #1 and #2) needs to be accomplished through a maximum of three field efforts being conducted during any given program time period.
- Some of the technical challenges associated with unconventional gas development (see Appendix D) will require advances in state of the art stimulation and reservoir imaging technology that may be difficult to achieve within the program time frame.

Strategies:

- Focus the Program – Prioritize to three geologic areas/basins to achieve impact. Evaluate the potential for adding technical resource and converting technical to economic resource and prioritize accordingly.
- Work with industry – Involving the producer community throughout the program from the early stages of planning through field testing is essential to assure a relevant program. Independent producers have specific and unique needs. Their "hands on" involvement is a necessity for impact.
- Plan a comprehensive program including all aspects required to accomplish the goal. Geology, geophysics, formation evaluation, drilling, completion, environmental and other disciplines need to be adequately addressed.
- Conduct ongoing planning and assessment. The ability to achieve results must be constantly monitored and assessed with respect to available resources. If experimental needs within the program relative to resources (funding) dictate further prioritization be implemented, e.g. limiting focus from three areas down to two areas, this must be accomplished.

Goal 3: Improve Resource Recovery

Develop technologies for improving unconventional resource recovery with minimum environmental impact.

Metric:

All technology developed within the program should be environmentally acceptable, i.e. less or no detrimental impact when compared to the techniques it replaces.

Objective:

Establish with initial solicitations and maintain throughout the program a requirement for all technologies developed to be at a minimum environmentally neutral relative to what they replace and more desirably an improvement. The program will encourage and favor technologies that mitigate environmental issues.

Barriers:

- Environmentally sound technology can add to cost and time of development.
- Environmental constraints and issues differ significantly from one area of the country to another.
- Technology developers may not be fully aware of all environmental issues or the full environmental impact of their products.

Strategies:

- A distinct and separate environmental component to the program will be established. It will be guided by the EAG and will serve to assure environmental compliance and mitigation throughout the balance of the research efforts.
- Solicitations will emphasize the need for environmental compliance and mitigation to the extent that technical approaches that threaten the environment or increase environmental impact will be considered non-responsive and rejected.

Goal 4: Increase Scientific and Technical Knowledge Base

Develop the R&D Program's science building capacity; develop significant industry support and participation; and develop a Program with a strong and successful technology dissemination component.

Metric:

The capacity of the program to increase the scientific and technical knowledge base available to address unconventional resource development will be measured by patents issued and published technical papers. The program should deliver three patents by 2010. An average of ten technical papers per year should be published in professional journals and industry publications. A longer-term metric more challenging to tie directly to the program would be an increase in university enrollment and faculty staffing in scientific and engineering disciplines relevant to unconventional resource development.

Objective:

By 2007, establish an appropriate intellectual property policy that encourages patent development and technical publications; plan and implement a technology dissemination program.

- By 2007, patent and IP policies are complete. Establish tracking mechanisms.
- By early 2008, establish a mechanism for measuring (quantifiable) producer participation in the program.

Barriers:

- Much of the R&D program is targeted for near term results. This will present a challenge for developing a program deep in basic science.
- Maintaining active producer involvement will be a challenge due to staff size of independent producers, their heavy workloads with drilling and other schedules, and their geographic diversity.
- IP policies can sometimes hinder product development and technology dissemination.
- The lack of stable funding for academic research in the relevant disciplines inhibits the development of a robust research infrastructure to develop new ideas and train the next generation of geoscientists and engineers who will implement new concepts.

Strategies:

- Appropriately designed research teams will be an important program component. The correct balance of academic idea generation and solutions must be integrated with near term and effective field based research. A programmatic approach to the research as opposed to individual projects will result in required impact and build the capacity for scientific and technical support of unconventional resource development.
- Program relevancy and outreach to the producer community is the most effective mechanism for maintaining involvement and will be central to technology dissemination plans. Successful product development that independents can use will attract and maintain their involvement.
- Professional societies (SPE, SEG, AAPG, etc.) will be engaged where appropriate within the programs and will be actively sought out for technology dissemination opportunities.
- Appropriate IP policy, favoring technology dissemination (i.e., small or zero royalty requirements) will be designed and implemented. Solicitations will emphasize patents where appropriate and contracts will address patent requirements.

As discussed in the Program Impact section of this document (Section 5), a structured approach will be used to calculate the impact of the technologies developed under the program on the reserve base. This approach will also be used to refine the goals and update them as additional resource targets might be added or program funding modified.

As noted in Goal 3, an objective of the unconventional resources program is reducing the environmental impact associated with unconventional natural gas exploration and production. While success in meeting this goal may be reflected in additional domestic gas reserves and production, a more explicit measure of reduction in environmental impact is desirable. A strategy within the RPSEA EAG is development of scorecards that are unique for each ecosystem found across the country. The scorecards will be used to estimate potential/actual environmental impact of prospective/deployed new technologies. The scorecards could have different indicators for program performance in the areas such as biodiversity, air, land, water, and human health. Research funding will be used to develop and maintain the scorecard system, against which environmental progress will be tracked.

Near, mid, and long term Program objectives
In order to ensure progress toward the strategic goals, near, medium, and long-term timeframes are defined. For the purpose of this program, near, medium, and long-term efforts are defined as those that produce tangible results in one to three, three to five, and five to ten years respectively. Descriptions of the primary goals of each program time element are as follows:

Near term (2007-2010)
A primary challenge facing gas producers today is the depletion rate and high cost. Rapid decline rates require that many new wells be drilled just to maintain production. The near term program will focus on existing plays with objectives including:

- Reduce the field decline rate by development of technology making new wells more productive.
- Develop techniques and technology for faster and less expensive drilling with minimum environmental impact.
- Reduce overall environmental impact from operations e.g., water management.

To address these objectives, activities associated with the near term will have a significant field-based component with supporting analytic work. Methods and techniques developed in this phase will be tested in the field through industry cooperative field work. This near-term research and development will be built on recent technology successes in various geographic/geologic areas and then advancing those technologies to the next level and broader dissemination of results. Near term projects will primarily focus on the later stages of any stage gate process i.e., field testing, technology dissemination and commercialization. As an example, microhole coiled tubing drilling has recently been shown to have significant impact through recent DOE programs. Another example of a relevant DOE program is the Environmentally Friendly Drilling Systems program, a collaborative effort designed to reduce environmental concerns in ecologically sensitive areas. Some of these tools and techniques could be expanded in their application through field demonstrations.

Mid-Term (2010-2012)
The program's mid-term objective is to identify resource targets for emerging unconventional resource plays. Emphasis again will be placed on industry cooperative field work. Identification and demonstration of low environmental impact techniques and procedures will be a priority. Working models developed through the near term program will be applied in new fields, modified as required, and documented to make the technology readily available to the industry. The measure of success will be the development of at least one new emerging resource area whereby a substantial portion of the technical resource will become a economic reserve.

Long-Term (2012-2017)
The long-term objectives of the programs are to develop techniques and methods for exploration and production from basins and formations where these operations have been hindered by technical, economic or environmental parameters. The program aims at identification and characterization of two or more resource-rich plays or basins with limited current activity. The goal is to provide enough information, knowledge, and methodologies to spur activity in currently undeveloped and low activity resources

allowing access to gas that is technically not feasible to drill and produce with current technologies.

D. Program Implementation

Planning and managing a successful research program is neither part-time work nor an adjunct to someone's business. Developing a new gas resource requires a broad and diverse group of participants. Some participants focus on generating new ideas and performing basic research. Others test concepts in the field and many participate in the dissemination and transfer of new concepts to the E&P industry. An area of past R&D program success in unconventional gas was the development of advanced technologies for gas production from coal seams. As mentioned previously, a successful R&D program resulted in coalbed methane production being developed from zero production and a hazard to coal mining to a significant source of domestic gas supply in a short period of time (Figure 3.2).

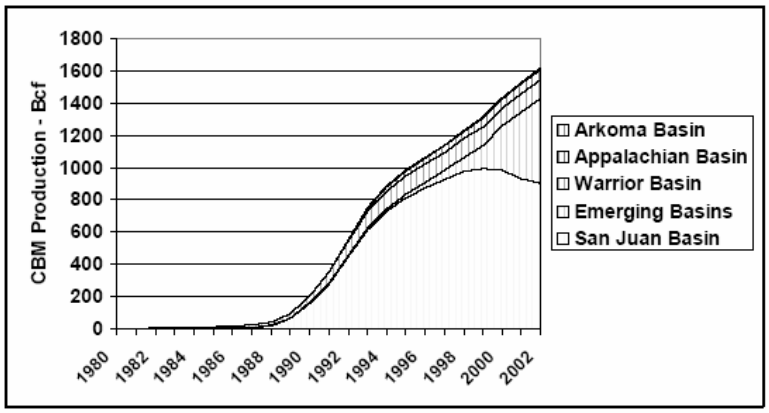


Figure 3.2 U.S. Gas Production from Coal Seams (From NPC, 2003. "Balancing Natural Gas Policy, Volume II, Integrated Report", National Petroleum Council.

Key to the success was industry participation in all stages of research and development, from concept development to field demonstration of results. In this fashion, research programs were based on industry needs, and industry experts monitored progress in a consistent manner in regular review meetings. Industry participated in field demonstrations and new technology testing activities.

This structure assured relevancy at all times while providing an effective technology transfer mechanism. Cost sharing by industry participants made it possible to embark on many otherwise cost-prohibitive field-based projects, without which early and effective technology transfer would have been impossible.

Criteria for a Successful E&P Research Program

The CBM research program consisted of a number of elements each closely coordinated with other elements. Program element implementation features include:

- *Integrated Program* - Many individual projects were performed. These were not isolated projects but integrated to achieve the benefits of a program.
- *Program Continuity and Funding* - A five-year vision with proposed funding was essential. This is not to say budgets are guaranteed. On the contrary, budgets were increased and decreased and projects initiated and terminated as necessary.
- *Planning and Management Process* – A disciplined process of planning and decision-making is required. Many research projects fail and require termination; others may be technically successful, but require significant redirection to achieve program goals. Rarely are these decisions simple. Failure is acceptable and desirable if properly managed.
- *Industry Participation* - Participation from industry to assure relevancy and to assist with technology dissemination concurrent with technology development could well be the single most important criteria. "Industry" in this case can be a producer, service company or contractor. A successful program will understand the differences of each sector and their differing business models. Industry participation in the form of gas well data, production statistics, well drilling and completion information from individual producers and wells of opportunity will also be strategic to any program. In many unconventional resources the acreage position is largely determined, so technology development benefits all and is not as great a competitive factor as it has been historically.
- *Program Coordination* - Program coordination will be required with other entities conducting research in the unconventional gas area and the producer community, in particular the independent oil and gas producers. This will be accomplished by two primary mechanisms: formation of a research advisory body, the Unconventional Onshore PAC and TACs. The advisory committees will assure the program is relevant and non-duplicative to ongoing research at E&P companies by representation and membership from these organizations. Regularly scheduled meetings should be conducted to review research progress, select projects, review strategy and assist with technology dissemination.
- *Regulatory barriers* – must be identified and understood early in the program development process as they have direct impact on technology solutions. As a simple example, it does no good to develop water processing technology that achieves 500 ppm chlorides if regulations require 50 ppm.
- *Technology Dissemination* - Developing any new gas resource that is technology dependent will need a focused effort to transfer results. The final phase of a research effort is to assure full commercialization and dissemination of the body of knowledge and practices developed through the research program. While these activities are initiated early (and need to begin early) in the research program they reached a crescendo during the later stages of the program. Commercialization activities include demonstration of technologies in the field and workshops and forums for technology

transfer. Publication of results via reports, dissemination of appropriate information to the press, presentations at industry association meetings and technology transfer meetings with individual companies are all an important part of the dissemination process.

Figure 3.3 below illustrates the components of the successful Coalbed Methane research program that led to a non-producing resource being developed through a technology program to where it is currently approaching 2 TCF of annual production in the United States.

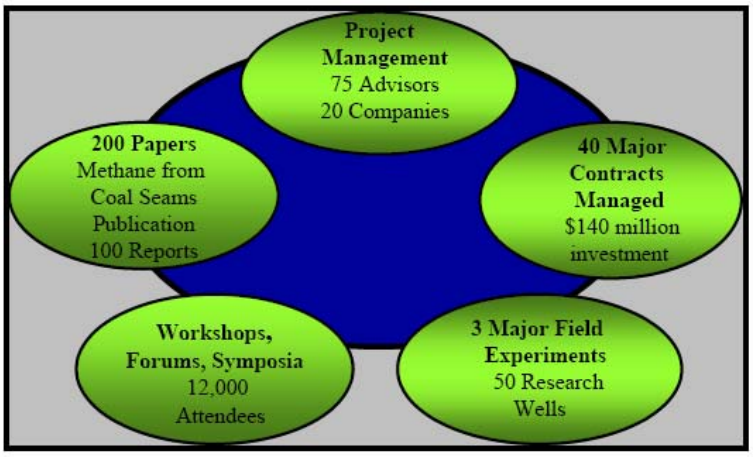


Figure 3.3 Past Coalbed Methane Research Program Elements

E. Role of RPSEA Advisory Committees

Each RPSEA program element functions uniquely. As described in Section 1, the Strategic Advisory Committee (SAC) provides long range strategic direction to the overall RPSEA program. The PACs and TACs process, constituency, and the role in which participants engage, is different for each program element. The Unconventional Onshore program utilizes its PAC and TACs as detailed below.

Program Advisory Committee

The RPSEA Unconventional Onshore PAC serves as the next level of advice below the SAC. It focuses on program priorities, field areas of interest, technology dissemination and provide a link to the producer and research communities, but its primary mission is project review and selection. The PAC met for its inaugural meeting February 6, 2007 in Houston, Texas. The committee is chartered for 12-15 members with ½ from the producing industry, ¼ from Universities and ¼ from the oil and gas service sector and venture capital firms. The current membership roster is included in Appendix A.

The Onshore PAC at this inaugural meeting discussed with RPSEA and debated amongst themselves a number of topics including: unconventional onshore resource opportunities and research priorities, strategic goals, near and long term objectives, identification of barriers and issues, development of strategy and approach, and determination of benefits/impact. A summary of their findings and recommendations to RPSEA regarding the Unconventional Onshore R&D program is found in Appendix D of this plan.

Technical Advisory Committee (TAC)

In the Unconventional Onshore program element, the solicitations will include components of an integrated effort to attack the technical challenges associated with targeted unconventional resources. The PAC will be responsible for selecting those proposals addressing issues that are most crucial to the success of the integrated program. In order to ensure that the selected proposals are of the highest technical quality, RPSEA will draw on the expertise of the specialized TACs for technical reviews.

For the Unconventional gas program the TACs will not be defined and officially convened until the technical program is underway and needs are identified. It is anticipated that these TACs will be formed, conduct their work and continue as long as needed relative to the technology area being reviewed. As the program changes and projects are completed individual TACs will be closed as new ones are formed, based on program need.

As planning for implementation of the TAC process, RPSEA has been soliciting member interest in serving on potential committees. A number of potential topics have been identified and members and others have expressed their interest. Over 100 technical experts representing all categories of RPSEA membership have expressed interest in serving on these TACs.

Table 3.2 lists the potential technical themes that may be associated with each of the targeted resources. A TAC structure aligned with these technical themes and the submitted proposals will be constructed drawing on the individuals that have expressed interest in serving on a TAC. The mix of proposals to be evaluated will determine whether discipline-oriented groups, interdisciplinary problem-focused groups, or some combination will be required.

Potential Technical Themes to be Reflected in TACs
Gas Shales
Rock properties/formation evaluation
Fluid flow and storage
Stimulation
Water management
Coalbed Methane
Produced water management
Tight Sands
Natural fractures
Sweet spots
Formation evaluation
Wellbore-reservoir connectivity
Surface footprint

Table 3.2. Potential Technical Themes to be Reflected in TACs

F. Prioritized Technology Needs

The previous description and material provided thus far in Section 3 have provided a framework for the needs associated with the prioritized resources identified for the Unconventional Onshore program. This section now refines those needs into the current Annual Plan. Multiple planning exercises and workshops have been conducted over the past two years as RPSEA prepared for the unconventional gas research program. Included were a series of three workshops sponsored by The U.S. DOE's National Energy Technology Laboratory (NETL), participation in National Petroleum Council technology studies, RPSEA forums and other venues. The following Table 3.3 summarizes the primary planning exercises used in the development of this Plan.

R&D Planning Event	Date	Description
RPSEA/New Mexico Tech Unconventional Gas Technology Workshops	Summer 2002	Five Workshops Conducted with Independents in Five Regions (San Juan, Permian, Mid-Continent, Appalachia, Rockies
National Petroleum Council 2003 Natural Gas Study	Study Conducted During 2002 - 2003	Comprehensive Evaluation of U.S. Natural Gas Resource Base Including Unconventional Gas
DOE Sponsored Unconventional Gas Workshops	Summer 2005	Three Workshops Conducted with Independents (Houston, Denver, Pittsburgh)
RPSEA Member Forums	Conducted 2006 - 2007	Multiple Meetings Involving Producers and Researchers for Input on R&D programs and Program Structure
RPSEA Program Advisor Committee Meetings	Inaugural Planning Meeting February, 2007	Planning Session where Unconventional Resources and Technology Needs were Identified
National Petroleum Council Global Oil and Gas Study	Study to be Completed Early 2007	RPSEA participation on Technology and Unconventional Gas Teams

Table 3.3 Summary of Unconventional Gas R&D Planning Exercises Conducted Over the Past Five Years

Each of these exercises and workshops resulted in comprehensive reports that RPSEA has utilized to help formulate Unconventional Resource R&D plans. The input is summarized in detail in Appendix D. The R&D program themes developed from an analysis of this input are described in the following section.

The workshops and studies on which the Unconventional Resource Plan for FY 2007-2008 is based produced a number of common themes which may be viewed in the context of time scale, resource priorities and technology priorities. The **Unconventional Onshore Research Program Themes** described below reflect the common issues associated with unconventional gas development in the United States. In order to ensure that research funds are invested for maximum impact over the duration of the program, the near-term, mid-term and long-term time scales associated with the program must be considered as described in the following **Program Focus** discussion. A focus on particular resources as described under **Resource Priorities** will ensure that program funding is not dispersed too broadly to have the desired impact. Finally, the resource priorities and the program time scale will define a set of **Technology Priorities**, which will form the basis for the initial solicitations.

G. Unconventional Onshore Research Program Themes

Several common themes emerged from the workshops and studies which form the nucleus of the Unconventional Gas Plan for FY 2007-2008.

- Unconventional gas is a large, technically difficult United States resource that is in need of a targeted research program to convert technically recoverable resource to economic production. The primary resources include: Tight Gas Sands, Coalbed Methane, and Gas Shales.
- All three resources are important but gas shales, the most difficult and least developed, was identified as a top priority. All three resources should be addressed and particular focus placed on leveraging technology across each resource.
- Gas shales, despite recent development such as the Barnett shale, are perhaps the most poorly understood unconventional gas resource type. In fact, uncertainties in resource evaluation approaches make it difficult to reliably estimate the size of the potential resource base associated with gas shales. Increasing our basic understanding of the factors governing fluid flow and storage in shales, combined with the development of appropriate production methods, will allow gas shales to make a significant, reliable and sustained contribution to the U.S. energy supply picture.
- Environmental issues and impact should be part of all aspects of technology development. In particular, water management issues surrounding coalbed methane and gas shales development should be a priority.
- The water production associated with coalbed methane has proven to be an impediment to the development of coalbed methane resources, even when the quality of the produced water is quite high. The development of methods for reducing the amount of water produced, as well as improved treatment would increase the opportunity for coalbed methane production and could be leveraged across gas shales.

- The program should be organized with a resource base focus, should be designed for near term results while including seed funding for longer-term research and should include significant and ongoing producer involvement and cofunding.
- Accessing resources due to environmental hurdles or economic hurdles is a priority issue. Extended reach drilling can minimize surface area and contact more resource (See Figure 3.4)
- Tight sands by definition have lower porosity and permeability than conventional reservoirs. Successful development requires exploitation of natural fracture networks and drilling, completion and stimulation methods to increase the effectiveness of the connection between the reservoir and the producing wellbore. Technologies that will aid in the detection of "sweet spots" and enhance the connectivity between the wellbore and the reservoir will result in higher recovery per unit of surface activity with the direct result of less environmental impact. These technologies should have high leveragability.

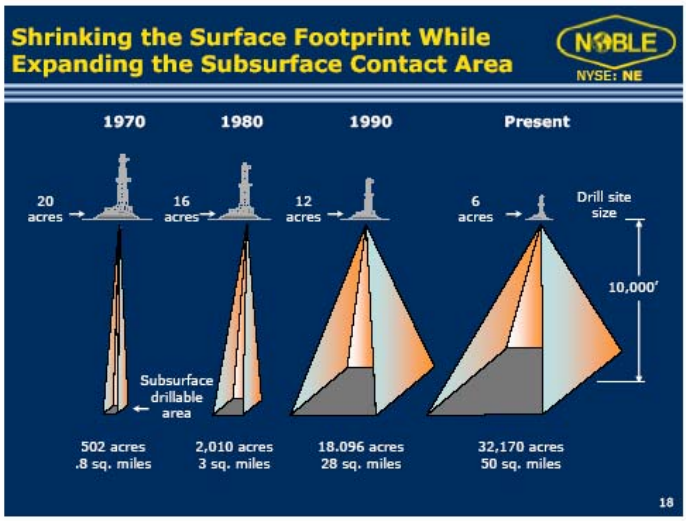


Figure 3.4 Reducing Surface Impact While Contacting More Reservoir – An Important Approach for Lower 48 Unconventional Gas Resources. (Courtesy Noble Drilling)

These primary themes resulted from the desire to maximize the energy produced as a result of the investment of research dollars, with an initial near-term focus. These are areas in which the potential resource is known, but currently uneconomic to produce. Further, the exploration and production industry has demonstrated a willingness to invest in the development of these resources when technologies become available to produce them economically.

Other opportunities for unconventional resource development will occur and will form a part of the longer term program. For example, it is likely that technology developed for the production of offshore resources in deep, hostile environments will find application in onshore deep gas

reservoirs. As the program develops, opportunities for investment in resources with a longer development horizon will be identified and included in the program.

H. Program Focus

The R&D program will focus on three types of unconventional gas resource plays:

- Existing Play - Active Development Drilling and Production
- Emerging Gas Play - Formations, depth intervals, or geographic areas from which there has been limited commercial development activity and very large areas remain undeveloped.
- Frontier Area - Formations, depth intervals, or geographic areas from which there has been no prior commercial development.

The resource and technologies priorities discussed below should be viewed in the context of these play types. The portion of the program devoted to existing plays will be aimed at producing results in the near-term time frame (2007-2010) and will focus on the application of existing or late-stage development technology in resources of current industry interest. Significant portions of the mid-term (2010-2012) program will be aligned with emerging resources, where the time scale will allow for some development of targeted technology, as well as novel applications of existing technology. For the emerging resources portion of the program, the specific resources to be targeted will depend upon the industry interest that develops as relevant new technologies move through the development cycle. The longer-term portion of the program (2012-2017) will focus both on frontier resources and earlier stage research and technology development. In order to lay the ground work for the longer-term, the program will include a component of funding for research that is not expected to yield results in the near to mid-term or is directed toward frontier resources with significant potential.

The resource and technology priorities summarized below are examples of the priorities determined at the time of the preparation of the plan (2007). While they are particularly relevant for the near-term program, and it is likely that field-based studies will focus quite early in the program on specific resource areas and technologies as outlined below, the priorities may be expected to evolve as the program progresses.

The unique properties and significant potential resource base associated with shales dictate that a significant effort be directed toward developing the technology necessary to understand and develop this emerging resource. Additionally, technologies that diminish the environmental impact of gas development or are directed toward exploration and production in tight formations will impact all potential unconventional gas resources. Technologies developed under the program will be mapped across all resources, irrespective of the initial area of resource application. Through this effort, technologies targeting a specific resource will find application in other regions of the country and for other resources, leveraging the R&D investment to the greatest extent possible.

I. Resource Priorities

Planning activities and other exercises have led to a prioritization of resources for the initial program. As indicated earlier, three categories of research; existing plays, emerging plays and frontier areas are identified with the priority plays noted for gas shales and tight gas sands. The specific play areas identified in Table 3.4 are examples of plays in which significant industry interest is likely to result in rapid investment in the application of R&D results to increase domestic production.

Once the program is established, it is anticipated that equal weighting will be given to existing and emerging gas plays with 45% of the program going to each category. The remaining 10% will focus on frontier areas. As discussed earlier, the 2007-2008 program is designed to have near term impact necessitating the emphasis on existing/emerging plays.

Table 3.4 identifies the resource/play priority by category.

Category	Program Balance	Priority Gas Shales	Priority Tight Sands
Existing Plays	**45%**	**Barnett**	**Green River**
		Appalachian	**South Texas**
			Uinta
Emerging Plays	**45%**	**Permian**	**Piceance**
		Woodford-Oklahoma	**Uinta Basin - Deep**
		Trenton-Black River	**Piceance Basin - Deep**
Frontier Area	**10%**	**Permian-Woodford**	**Western Oregon**
		Green River	**Washington**

Table 3.4 Resource Area Priorities

Discussion around the topic of coalbed methane identified it as an important resource and in need of focused research as with the other resources. This is to be achieved through several steps:

- Leverage all technologies across all resources including coalbed methane. In particular, environmental projects associated with water management will be targeted for CBM applications.

- Field activities in the Rockies and Appalachian areas will encounter all three resources. As a result, technology development should and will address the unconventional "resource package" including CBM.

- The resource priority identified in Table 3-4 is an initial prioritization. Planning and program adjustments will be conducted on an ongoing basis. Opportunities for greater CBM emphasis as warranted will exist.

J. Technology Priorities

Planning exercises were also conducted for technology areas. Table 3.5 is a list of specific technology issues associated with particular unconventional gas resources. The focus was to identify the technology issues associated with the resources identified. No attempt was made to identify the solutions to these issues; a function to be left to the research proposed through the solicitation process. This portfolio of issues will be drawn upon as specific solicitations are prepared for targeted resources.

Technology Issues	Tight Gas Sands	CBM	Gas Shales	Priority Area
Reservoir Characterization				
Permeability/producibility in tight formations: controls, distribution and prediction	X	X	X	P
Gas storage in shales: mechanisms and controls			X	
Fracture characterization in shales and tight sands	X		X	
Coalbed methane permeability				
Seismic imaging of complex structures	X	X	X	
Drainage areas – radial or elliptical	X	X	X	
Geologic/geochemical controls on shale properties			X	P
Analytic models for desorption, gas/condensate behavior		X	X	P
Advanced formation evaluation tools and methods	X	X	X	
Technology for development of thin gas stringers	X	X	X	
Core sampling and measurement procedures				
Review public data with "new eyes" (data mining)	X	X	X	
Identification of "free gas" versus shale gas			X	
Drilling and Completion				
Best practices/optimized production methods; environmental, drilling, completion, stimulation	X	X	X	
Stimulation: design and modeling	X	X	X	P
Formation damage prevention and mitigation	X	X	X	
Low impact/high performance drilling	X	X		
Real time drilling data acquisition	X	X	X	
Drill bits for less wellbore damage				
Application of coiled tubing and Microhole technology		X	X	P
Horizontal/directional drilling technology		X	X	
Multi-lateral drilling		X	X	P

Technology Issues	Tight Gas Sands	CBM	Gas Shales	Priority Area
Real time data gathering while drilling	X	X	X	
Application of reverse circulation drilling				
Environmental				
Surface disturbance including well sites and roads	X	X	X	P
Air quality related to oil and gas operations	X	X	X	
Groundwater quality, Produced Water clean-up	X	X	X	P
Impact of oil and gas operations on wildlife	X			
Cuttings Disposal and Waste Management	X	X	X	
Water Management				
CBM – surface discharge; soil chemistry issues, treatment limits		X		
CBM – treatment and beneficial use		X		P
Water shutoff: improved chemical treatments		X	X	
Improved re-injection methods				
Cost effective application of reverse osmosis or alternative desalinization methods		X		
Inhibiting water production from fractures without impeding oil or gas production		X	X	P
Identify new sources of water for oil and gas operations	X	X	X	
Cost effective and reliable downhole separation methods		X	X	
Pumping large volumes of water/fines for CBM		X		P
Resource Evaluation				
Classify what reservoirs work and why	X	X	X	P
Improved methods to learn from drilling results and identify sweet spots				
Natural fracture importance and detection	X	X		
Pressure measurement in low-perm rocks; core analysis, define the plumbing system	X		X	
How to model shales the way we model sands – materials + fluids + chemistry			X	P

Table 3.5 Technology Challenges and Issues Associated with Unconventional Gas

K. Coordination with complementary NETL program

The 2007-2008 RPSEA program is focused on developing unconventional gas from shales and tight sands, and addressing produced water issues associated with coalbed methane development, primarily in existing and emerging resource areas. The NETL complementary program will be focused on longer-term technology developments that might be applied in other unconventional resources, such as onshore deep gas. While it is anticipated that approximately

10% of the RPSEA program funding will be devoted to technology aimed at frontier resources, there may be additional opportunities through the RPSEA program to evaluate the potential for the application of results from the NETL program in emerging and frontier resources. RPSEA will coordinate with NETL management and researchers, as well as the RPSEA advisory structure, to identify opportunities where work conducted under the RPSEA program might facilitate the introduction and enhance the impact of technologies developed through the NETL program.

L. RPSEA Unconventional Resources Planned Solicitations

RPSEA plans to issue multiple solicitations throughout the period covered by the FY 2007-2008 Annual Plan. The initial solicitation will cover the areas of Gas Shales, Tight Sands, and Water Management in Coalbed Methane and Gas Shales. As the R&D program gets underway in a particular region or resource area, RPSEA anticipates that R&D issues not initially identified may develop resulting in the need for additional solicitations. Solicitations will reflect the desire to establish a balanced research portfolio to reflect an appropriate mix of science, enabling, enhancing and "Grand Challenge" projects.

A simple example can be described around water issues in the Barnett shale. The exact type of water and issues surrounding water usage and recycle were not understood until significant development and operations had been undertaken. The ability to identify all issues related to drilling, completion, environmental, etc., a priori is near impossible. Therefore, RPSEA will use a flexible approach issuing solicitations as needed based on need.

As the program is initiated, early solicitations will be broad in scope, allowing a broad range of research topics addressing key issues to be considered. The Objective, Goal, Description and Scope for each of the areas of interest for the initial planned solicitation are summarized below. A more complete description of the solicitation process is included in Appendix B. As the program matures, subsequent solicitations will address more detailed and specific problems, building on earlier program successes It is also anticipated that the RPSEA management team may need to form research teams to effectively address individual problems. Past R&D experience has shown that the best entity to perform a specific scope of work does not always exist and must be developed.

1. Area of Interest: Gas Shale

Development of Existing and Emerging Gas Shale Plays

Objective:
Develop tools, techniques and methods that may be applied to substantially increase commercial production and ultimate recovery from the established gas shale formations (priority 1) and accelerate development of emerging and frontier shale gas plays (priority 2.)

Goal:
Increase the technically recoverable resource base associated with gas shales and the size of the economically recoverable gas shale resource by reducing environmental impact and costs associated with gas shale development.

Description:
A significant fraction of the natural gas stored in most producing shale formations is sorbed onto shale particles rather than occupying the natural fracture system. Natural gas flowrates from the shale into the wellbore are too low to render the wells economical and certain production stimulation applications (primarily hydraulic fracturing) are needed to increase the rate to commercially acceptable levels. Although specially designed drilling and completion techniques have resulted in high production rates from the fracture system, because the influx of desorbed gas from the bulk of the formation into the fracture system is very slow, production rates decline rather quickly to below commercially sustainable rates. As a result, it is estimated that up to 90% of the gas in place remains as unrecoverable.

Shale reservoirs often require stimulation through hydraulic fracturing or other methods to increase permeability. Considerable volumes of water and other fluids may be used during stimulation operations, and these fluid volumes may ultimately be returned to the surface. Stimulation methods that require less fluid to be injected and ultimately produced to the surface would be beneficial, as would improved methods for the treatment and disposal of fluids brought to the surface during stimulation operations.

Recent development of the prolific Barnett shale in Forth Worth basin, coupled with the high market price for natural gas, has raised the industry's interest in other shale plays such as the Permian basin with Barnett and Woodford shales of west Texas and Lewis and Mancos shales in the Rocky Mountain region. The fundamental difference between the emerging gas shale plays such as the southwest Texas Barnett and the established plays such as the Forth Worth Barnett lies in the fact that emerging gas shale resources have not been fully characterized, reliable estimates of gas in place are not available, and the production potential is unknown. As a result, serious capitalization by the industry faces unknown economic risks.

The success at the Barnett play was achieved after nearly fifteen years of study, experimentation, and field trials. It is the purpose of this program to accelerate this process for emerging plays by building on the past success to use the knowledge gained and the approaches developed at successful sites, while maximizing the learning from failed approaches.

It is anticipated that the greater portion of research and development efforts in the earlier years will be focused on resource characterization resulting in reliable reserve estimates, geologic and geophysical studies for fracture delineation and sweet spot detection, and development of drilling and completion techniques. In addition, significant efforts will likely be devoted to basin and reservoir studies that will ensure that promising emerging and frontier resources are positioned to contribute to meeting program goals in later years. Additionally, some portion of the effort is expected to be devoted to longer-term research on some of the key issues identified below, with the potential to yield novel solutions leading to application in the later years of the program.

Other factors hindering commercial production from gas shale formations are the high initial capital expenditure for drilling and completion, environmental concerns, large

volumes of water needed for drilling and fracture stimulation; and produced water disposal and management.

RPSEA plans to issue a series of solicitations addressing a selection of issues that are considered as being highly influential relative to development of gas shale resources of the lower 48 States.

Scope:
Proposal solicitations in the gas shale program area will request ideas and projects for development of tools, techniques and methods that may be applied to substantially increase, in an environmentally sound manner, commercial production and ultimate recovery from the established gas shale formations (priority 1) and accelerate development of emerging and frontier gas shale plays (priority 2) The concepts may include but will not be limited to the following areas:

- Determination and quantified characterization of geologic, geochemical, and geophysical, and operational parameters that differentiate high performing wells from poor performers and using the knowledge thus obtained for design of operations to counter the effects of the local parameters that hinder commercial production in the poor areas.
- Development of methods to accurately assess the potential of a shale for gas production from petrophysical measurements.
- Development of methods to plan, model and predict the results of gas production operations from geologic, petrophysical and geophysical data.
- Accurate delineation of the natural fracture system for guiding horizontal wells to intersect a large number of open fractures.
- Development of extra-extended single and multi-lateral drilling techniques.
- Development of steerable hydraulic fractures.
- Development of suitable fracturing fluids and proppants; e.g., non-damaging fluids and/or high strength low density proppants.
- Development of drilling and completion techniques that eliminate or minimize environmental impacts of the drilling and completion operations; e.g., single pad multiple well similar to offshore operations.
- Develop stimulation methods that require less water and other fluids to be injected into the subsurface.
- Develop stimulation methods that result in a lower volume of treatment fluids produced to the surface.
- Develop approaches for improved treatment, handling and disposal of fluids produced to the surface.

- Development of efficient and safe water management schemes.

- Extending the commercial life of a producing well through reduction of the initial drilling and completion costs, elimination of workovers and recompletions, as well as reduction of production costs particularly those associated with water disposal and management.

Deliverables:
Anticipated deliverables from worked performed under this solicitation include but are not limited to the following:

- Reports including detailed process, procedures, software, manuals, and guidebooks and the like documenting the success or failure, and clearly explaining the cause-and-effect rationale for the observed results. Identification of analogous plays where the same procedures can be implemented.

- For projects involving innovative and commercially producible hardware, software, or processes, early identification of commercialization path will be imperative.

Technology Transfer:
Effective technology transfer will be essential and is considered a highly valued deliverable from the work. Early and continued producing and service company participation, and cooperative field work have been a key element of success in the past and should be pursued. Other technology transfer efforts include preparation and presentation of technical papers, workshops, and seminars. The researchers may be required to create and maintain open access web-based training facilities with an appropriate level live supervision. RPSEA will maintain a publicly accessible web page that will house all reports and data resulting from the work. Research contractors shall be required to submit reports and data in electronic format for immediate access by the industry, co-researchers, all academic and technical institutions and individual researchers and consultants.

2. Area of Interest: Water Management

Managing the Produced and Utilized Water Associated with Coalbed Methane and Gas Shale Production.

Objective:
Develop tools, techniques and methods that may be applied to facilitate the development of coalbed methane and gas shale resources through improving the management of subsurface water brought to the surface as a result of production and minimzing the impact of local water utilization during operations.

Goal:
Decrease the water volume subject to surface disposal as a result of development of a targeted resource. The reduction in disposal requirements may be achieved through a reduction in produced water volumes, development of improved subsurface injection

technology or development of a sustainable beneficial use approach, which in turn will minimize local water usage.

Description:
Water is associated with coalbed methane and gas shale production in all geographic areas. Even in cases where the water quality is excellent, introducing produced water to the surface environment has consequences. Methods of treating and handling produced water that result in sustainable beneficial use or reinjection into the subsurface at a cost that does not impede development of the associated gas resources must be developed.

Scope:
Proposal solicitations in the water management area will request proposals for development of tools, techniques and methods that may be applied to substantially decrease the environmental impact of produced and used water associated with coalbed methane and gas shale development. The concepts may include but will not be limited to the following areas:

- Develop methods for the treatment and sustainable beneficial use of produced water.
- Develop methods to deal with produced water and control fines.
- Develop techniques to minimize the volume of water produced to the surface.
- Develop approaches for improved treatment, handling and disposal of fluids produced to the surface.
- Extend the commercial life of producing coalbed methane and gas shale wells through reduction of the initial drilling and completion costs, elimination of workovers and recompletions, as well as reduction of production costs particularly those associated with water disposal and management.
- Thin bed coal seams require a unique approach for both drilling and completion. Develop methods effective for thin beds.

Deliverables:
Anticipated deliverables from worked performed under this solicitation include but are not limited to the following:

- Reports including detailed process, procedures, software, manuals, and guidebooks and the like documenting the success or failure, and clearly explaining the cause-and-effect rationale for the observed results. Identification of analogous plays where the same procedures can be implemented.
- For projects involving innovative and commercially producible hardware, software, or processes, early identification of commercialization path will be imperative.

Technology Transfer:
Effective technology transfer will be essential and is considered a highly valued deliverable from the work. Early and continued producing and service company

participation, and cooperative field work have been a key element of success in the past and should be pursued. Other technology transfer efforts would include preparation and presentation of technical papers, workshops, and seminars. The researchers may be required to create and maintain open access web-based training facilities with an appropriate level live supervision. RPSEA will maintain a publicly accessible web page that will house all reports and data resulting from the work. Research contractors shall be required to submit all their reports and data in electronic format for immediate access by the industry, co-researchers, all academic and technical institutions and individual researchers and consultants.

3. Area of Interest: Tight Sands

Development of Existing and Emerging Gas Plays in Tight Sands

Objective:
Develop tools, techniques and methods that may be applied to substantially increase commercial production and ultimate recovery from established tight gas sand formations (priority 1) and accelerate development of emerging and frontier tight gas sand plays (priority 2).

Goal:
Increase the technically recoverable resource base associated with tight gas sands and the size of the economically recoverable tight gas sand resource by reducing environmental impact and costs associated with tight gas sand development.

Description:
While tight gas sands represent the bulk of domestic unconventional gas production, many tight gas resources remain uneconomic. In general, natural gas flow from tight gas formations into wellbores is too low to render the wells economical and certain production stimulation applications (primarily hydraulic fracturing) are needed to increase the rate to commercially acceptable levels. Natural fracture systems and other areas of enhanced permeability that can increase gas production are difficult to identify prior to drilling, resulting in a higher than desired number of uneconomic or marginally economic wells. Although specially designed drilling and completion techniques may result in high initial production rates from the fracture system, low matrix permeability causes production rates to decline rather quickly to below commercially sustainable rates. As a result, it is estimated that significant portions of the gas in place remain unproduced.

Operations associated with drilling and producing tight sand reservoirs have some degree of impact on surface land characteristics. This impact may be minimized by increasing the volume of reservoir that may be accessed from a single surface location or by decreasing the "footprint" associated with each individual surface location. This issue is particularly critical in tight reservoirs in which each subsurface reservoir penetration may drain a relatively small portion of the reservoir. Advanced drilling, completion and stimulation methods have the potential to both increase the volume of reservoir accessed from a single surface location and decrease the environmental impact associated with each location.

It is anticipated that the greater portion of research and development efforts in the earlier years will be focused on resource characterization resulting in reliable reserve estimates, geologic and geophysical studies for fracture delineation and sweet spot detection, and development of drilling and completion techniques. In addition, significant efforts will likely be devoted to basin and reservoir studies that will ensure that promising emerging and frontier resources are positioned to contribute to meeting program goals in later years. Additionally, some portion of the effort is expected to be devoted to longer-term research on some of the key issues identified below, with the potential to yield novel solutions leading to application in the later years of the program.

Scope:
Proposal solicitations in the tight gas sands program area will request proposals for development of tools, techniques and methods that may be applied to increase commercial production and ultimate recovery from established tight gas sand formations (priority 1) and, accelerate development of emerging and frontier tight gas plays (priority 2.) The concepts may include but will not be limited to the following areas:

- Determination and quantified characterization of geologic, geochemical, and geophysical, and operational parameters that differentiate high performing wells from poor performers and using the knowledge thus obtained for design of operations to counter the effects of the local parameters that hinder commercial production in the poor areas.
- Accurate delineation of the natural fracture system for guiding horizontal wells to intersect a large number of open fractures.
- Development of extra-extended single and multi-lateral drilling techniques.
- Development of steerable hydraulic fractures.
- Development of suitable fracturing fluids and proppants; e.g., non-damaging fluids and/or high strength low density proppants.
- Development of drilling and completion techniques that eliminate or minimize environmental impacts of drilling and completion operations; e.g., single pad multiple well similar to offshore operations.
- Develop advanced drilling, completion and/or stimulation methods that allow a greater volume of reservoir to be accessed from a single surface location.
- Develop drilling, completion and stimulation methods that decrease the environmental impact associated with each surface location
- Development of efficient and safe water management schemes.
- Extending the commercial life of a producing well through reduction of initial drilling and completion costs, elimination of workovers and recompletions, as well as reduction of production costs, particularly those associated with water disposal and management.

Deliverables:
Anticipated deliverables from worked performed under this RFP include but are not limited to the following:

- Reports including detailed process, procedures, software, manuals, and guidebooks and the like documenting the success or failure, and clearly explaining the cause-and-effect rationale for the observed results. Identification of analogous plays where the same procedures can be implemented.

- For projects involving innovative and commercially producible hardware, software, or processes; early identification of commercialization path will be imperative.

Technology Transfer:
Effective technology transfer will be essential and is considered a highly valued deliverable from the work. Early and continued producing and service company participation, and cooperative field work have been a key element of success in the past and should be pursued. Other technology transfer efforts would include preparation and presentation of technical papers, workshops, and seminars. The researchers may be required to create and maintain open access web-based training facilities with an appropriate level live supervision. RPSEA will maintain a publicly accessible web page that will house all reports and data resulting from the work. Research contractors shall be required to submit all their reports and data in electronic format for immediate access by the industry, co-researchers, all academic and technical institutions and individual researchers and consultants.

Section 4

SMALL PRODUCER PROGRAM ELEMENT

A. Small Producer Program Element Mission

The Small Producer program element shares the overall program mission to increase the supply of domestic natural gas and other petroleum resources through reducing the cost and increasing the efficiency of exploration for and production of such resources, while improving safety and minimizing environmental impact, with a specific focus on addressing the technology challenges of small producers.

B. The Small Producer

EPACT requires that all awards under the Small Producer program element "shall be made to consortia consisting of small producers or organized primarily for the benefit of small producers". All solicitations issued will include the requirement that proposals be submitted by a consortium consisting of two or more entities participating in a proposal through prime contractor-subcontractor or other formalized relationship that ensures joint participation in the execution of the scope of work associated with an award. Simple consortia are planned that include simple partnering agreements with each consortium highly encouraged to have a minimum of one small producing company participating. A small producer is defined as a U.S. Company producing less than ≤ 1000 BOEPD. The primary focus of the program will be technology development in mature oil and gas fields with the objective of extending the life and ultimate recovery of the fields.

There are thousands of independent oil and natural gas producers across the United States. Independent producers develop 90 percent of domestic oil and gas wells, produce 68 percent of domestic oil and produce 82 percent of domestic natural gas (IPAA). Independents have been responsible for all of the major onshore discoveries since 1990. A recent analysis has shown that independent producers are investing 150 percent of their domestic cash flow back into domestic oil and natural gas development—borrowing funds to enhance their already aggressive efforts to find and produce more energy. According to data from the Energy Information Administration (2006), approximately 15% of the nation's oil production comes from the well over 10,000 small producers whose production averages less than 1,000 barrels per day, who in 2005 produced over 250 million BO.

The domestic "upstream" part of the petroleum and natural gas industry – exploration and production or E&P – is characterized by thousands of companies operating in over 30 states. Overwhelmingly, these "independent" explorationists and producers receive revenues only from these upstream activities. Most employ fewer than 20 employees, but collectively, they are critical to future domestic supply. These small producers in particular are focused on maximizing the value of the assets they currently hold. The desire of small producers to extract the maximum value from their asset base is precisely aligned with the general goal expressed in

paragraph (a) of Section 999B of EPACT "to maximize the value of natural gas and other petroleum resources of the United States".

Domestic petroleum and natural gas production has changed over the years, particularly since the mid-1980s. Maturing production areas in the lower 48 states and the need to respond to shareholder expectations have resulted in major integrated petroleum companies shifting their exploration and production focus toward the offshore United States and foreign countries. More and more, these large companies must rely on large producing fields that are found only in frontier areas. Consequently, domestic production in the lower 48 states is an area where the role of independents is increasing. For example, the independent share of the lower 48 states petroleum production has increased from 45 percent in the mid-1980s to over 60 percent by 1995; these states, despite their mature fields, still account for 60 percent of domestic oil production.

Finally, the fundamental uniqueness of independent producers and their role in supplying the nation's energy must be recognized and addressed. The price instability of the past four years demonstrates the scope of this challenge. Failure to respond to the low prices of 1998-99 has resulted in the loss of 700,000 barrels per day in domestic production – largely from the permanent closure of marginal wells that become uneconomic at low prices. Cuts in capital investment led to higher oil and natural gas prices in 2000-2001. As the nation now grapples with questions of national security, it cannot afford further losses in domestic oil production and reduced domestic capital spending to find and produce natural gas. The United States needs to recognize the needs of the small independent producer along with the maturing nature of our domestic oil and gas resources. Technology to assist the small producer in developing mature resources is the primary focus of the RPSEA small producer program.

C. Resource Opportunities and Priorities

Current studies estimate that oil and gas from mature assets will account for more than one-half of the global energy mix for the next 20 years, and probably much longer. It is imperative that the industry address the important issues of mature asset development and continue to develop the technology that will drive those developments.

Mature oil and gas fields are defined as those in a state of declining production or reaching the end of their productive lives. They are typically over 30 years old. They are important in that they account for 67 to 72 percent of world production and, therefore, represent a significant resource to provide future production while utilizing existing infrastructure. In the United States in 2005, marginal wells produced 17% of domestic oil and 9% of the natural gas. The technically recoverable resource for this category has not been adequately characterized. DOE estimates however that two thirds of oil production remains after conventional production and half of that is at depths less than 5000 feet. This remaining discovered resource is estimated to be greater than 400 billion barrels of oil located in mature geologic basins in the U.S.

Mature fields were brought on stream decades ago, and in many cases, new technology has not been applied to them. The goal has been to maintain production with little investment, but this is changing due to increased demand.

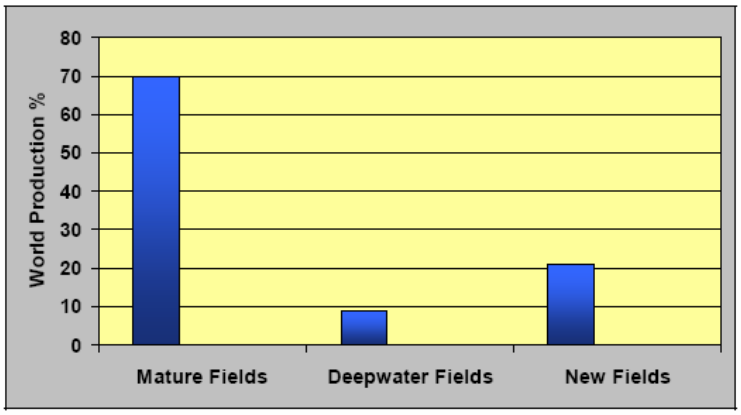


Figure 4.1 Percentage of World Production from Mature Oil and Gas Fields (Adapted from: Brownfields—tools to manage the challenges; 2004 Schlumberger Information Solutions, Houston, Texas.

It is the goal of the RPSEA small producer program to initiate a technology program to address this valuable resource. This development is to be conducted with the producer group in the United States who develops a majority of this resource – the independent producer. In particular the small producer (1000 BOEPD or less), who is without the resources to develop enabling technology, will be the primary program participant.

Mature Field Challenges
There are several aspects to mature field development that are uniquely challenging:

- Data is collected and interpreted over a long time period. Automated data monitoring and analysis using newer techniques offer the opportunity to detect subtle but important anomalies.
- A huge amount of production data is available. How to manage and assess that data rapidly to make proactive, rather than reactive decisions, especially given the growing ability to receive data real time, is important.
- Reservoir models and simulations of reservoir behavior are typically updated infrequently, so they are often out of date and not cost effective for most of the small fields operated by small producers.
- Goals to reduce expenditures as the field declines are at odds with the need to drill increasingly complex wells to access bypassed reserves or to ensure successful secondary or tertiary recovery programs and to maintain or upgrade obsolete facilities.

- Business models need to be holistic in nature, encompassing everything from the field to the facilities, since access to appropriate facilities is crucial to continuing business viability.

- Many of these fields have been sold to and are operated by small producers who do not have the resources or the technical expertise to fully develop these fields. The large service companies have by and large abandoned many of these areas in pursuit of higher profit margins, creating a technical service gap.

- Drilling in these depleted reservoirs is a significant challenge; it requires drilling more wells (infill drilling) and applying underbalanced drilling. There is a challenge to protect groundwater, minimize environmental impact to the site and mitigate the problem of poor surface casing and poor cementing. There are significant needs for smaller, faster and less expensive rigs. The cost of drilling and re-drilling is possibly the primary barrier to developing these known resources.

- Mature fields provide a primary area for the sequestration of CO_2, thus all of the challenges of handling CO_2 and its injection must be addressed. The opportunity to sequester CO_2 while increasing hydrocarbon recovery exists, if new technology can make the economics attractive.

- Reduced operating expenses and improved practices directly translate into increased ultimate recovery. In many smaller fields with only a few wells, reducing cost is the primary practical approach to increasing reserves and production.

It will be important to identify and effectively demonstrate commercial off the shelf technology that can increase oil and gas production in existing fields while reducing the environmental impact of drilling and completion operations. In the mid-term, development of new technologies that can extend current production limits, produce more gas through existing infrastructure, and mitigate past and current environmental issues will be important.

A detailed analysis of these areas, in conjunction with the application of the appropriate technology bundles, can make the mature field business more profitable and sustainable. Improving operational processes through the use of new technology does not have to be a leap of faith. There are many examples of how applying the right tool set, along with changes in working practice, leads to dramatic improvements in production and bottom-line performance.

Mature fields can be large and operated by major companies (e.g. North Slope fields). Many of the U.S. lower 48 fields are operated by small producers and the opportunities are of the size in which the major companies show little interest. Some of the challenges faced by the small producer need to be addressed by a focused R&D program with technologies designed specifically for small producers.

One of the major characteristics of a mature field is the wealth of production information spanning the life of the field, from the original pressure test data to the current producing rates. Good information management practices can make data access easy, reliable and fast. The answer to optimizing production in mature fields is to move from purely monitoring and surveillance modes to a proactive analysis mode. The challenge is to know what to analyze and when, and to develop protocols and tools useable by small producers.

Typically, in an effort to maximize recovery from a mature field, some type of drilling or well intervention program is needed, whether to access bypassed reserves or to facilitate a more effective secondary recovery program. At this stage of the field life, the challenge is to maximize the cost effectiveness of each of these operations. Several technology enablers contribute to this goal. One of the key challenges in designing complex wells is to get improved interdisciplinary collaboration between engineering and geosciences.

Being able to run multiple scenarios of the whole system from reservoir to facility with full risk and cost implications is critical. Since the production facilities and their capabilities play a large role in mature field success, they must be included. One of the key challenges is optimizing production from existing fields while the facilities are still in good working order. The key in this area is to be able to practically model 'what-if' scenarios for additional wells and production. Without an integrated workflow and supporting software, field-level economic evaluations can be onerous. Tools to support these activities must be tailored to small producer needs.

Significant improvement in the ability to manage mature assets can be realized through the application of appropriate technology and embracing applicable new working practices. This extends the lives of the fields, increases ultimate recoveries and adds to the nation's reserve base.

D. Strategic Goal

The strategic goal of the small producer program element is to achieve a positive benefit to the U.S. energy consumer through adding to the reserve base associated with mature fields operated by small producers an amount of new reserves equal in value to ten times the R&D investment in the small producer program element over the course of the program. These reserve additions will result from increasing the recovery factor, applying technology to make economically marginal resources economic and decreasing the impact of development in environmentally sensitive areas.

In order to maximize the impact of the program on increasing the value of the assets held by small producers, a key feature of the program is the collection of inputs from a Research Advisory Group (RAG) of small producers who will focus on identifying, targeting, and prioritizing specific technology needs. This advisory group will also provide a key communications focal point for encouraging the formation of the requisite research consortia.

The program will be near term in nature. It is anticipated that research contracts and deliverables will have a 1-3 year timeframe. The program strategy within the small producer area is not focused on the development of new technology from scratch but rather the adaptation of existing technology for use by the small producer. This will include off-the-shelf technologies that require modification for effective utilization by the small producer. The program does not preclude development of entirely new techniques or approaches but any proposed will need to fit the near term timeframe for development.

Technology themes include:

- Development of approaches and methods for water management, including produced water shutoff or minimization, treatment and disposal of produced water, fluid recovery, chemical treatments and minimizing water use for drilling and stimulation operations.
- Development of methods for improving the oil and gas recovery factor.
- Development of techniques that will extend the economic life of a reservoir.
- Development of methods to reduce field operating costs, including reducing production related costs as well as costs associated with plugging and abandoning wells and well site remediation. Consideration will be given to those efforts directed at minimizing the environmental impact of future development activities.

Goal – New reserves
Achieve a 10 to 1 ratio for new reserves to R&D investment for the small producer program.

Objectives:

- Develop technologies that will aid small producers to maximize the value of their mature asset base by increasing production and recovery factor and improving the economics associated with currently marginal resources associated with that asset base. Achieve a projected 10 to 1 benefit to cost ratio by year two and maintain or exceed that ratio throughout the program.
- Focus the program on overall field strategies and technologies as opposed to wellbore specific problem areas. Technology areas include overall water management, extending field life, environmental mitigation, corrosion management and reduced operating costs.
- Include a highly leveraged technology transfer component, which requires collaboration with existing successful technology transfer organizations, as well as communicating this information to as many small producers as possible through numerous media, preserving a primary objective of technology development.

Barriers:
The small producers present a unique set of challenges that limit their ability to develop and adopt new technology. These include:

- The over 10,000 small producers are dispersed around the country, operating in over 30 states.
- They have limited access to capital and rely heavily on their own company cash flow and risk averse bank debt to finance projects.
- They have a shortage of engineers, geologists and landmen. These professionals are spread thin with multiple responsibilities for multiple fields.
- A small producer who develops technology may not have sufficient fields or wells over which to amortize the cost and risk.

- They operate in multiple regulatory jurisdictions with regulations unique to the areas in which they are active.
- They have no internal research capability due to their size and financial constraints.
- Most do not have the resources or capability to internalize new technology, especially complex techniques requiring significant time investments.
- Small producers are threatened by technical, environmental, and market challenges that are constantly changing and rarely becoming simpler.
- Small producers are also extremely busy and averse to administrative tasks associated with participation in government programs.

Strategies:

- Focus on field-wide strategies for enhanced recovery. Solicitations will request field-wide problem identification and specific solutions. For example, if an individual field has a field-wide corrosion problem the R&D will focus on that issue, with producer and researcher involvement (via a consortium) to resolve the corrosion issue thus reducing cost and extending reservoir life. Additional topics include water management, environmental mitigation, enhanced reservoir characterization and others. Technical issues will not be proscribed in solicitations but field-wide problems and solutions emphasized.
- Small producers lack the staff to internalize complicated technology, so technology transfer must involve appropriate service providers. The program will address further development of existing technology with the goal being simplification of use as part of the overall approach to the small producer challenges.
- A consortium approach will be utilized to overcome individual small company limitations. The approach recognizes that there may be little potential for cash matching funds from small producers due to their financial constraints but a history of in-kind contributions and a willingness to participate in field based research experiments will be drawn upon as an important program implementation step. Small producers tend to be very willing to take risks and try new things by their nature, and often times their low volume wells have little to lose in experimenting.

Metrics to demonstrate goal and objectives achievement, including Program Impact can be found in the Program Impact section of this Annual Plan.

E. Small Producers Technology Program

The following section describes the FY 2007-2008 program and technology challenges for the Small Producer program element. As discussed above, the program will focus advancing technology and increasing the production from mature fields operated by small producers through the application and development of technologies to decrease operating cost and increase recovery from such fields and extend their producing life. The planned program is intended to maximize the contribution of the mature hydrocarbon assets held by small producers to the nation's energy supply, while minimizing the environmental impact associated with production of these resources, which reside in areas already subject to energy development. The predominate developer of the resource is the small independent oil and gas company, and as such it is an objective of the program that technologies developed be usable by this industry segment.

F. Role of RPSEA Advisory Committees

Small Producers Research Advisory Group
The Small Producer program will receive guidance from a Small Producer Research Advisory Group (RAG) consisting of industry and academic representatives that are closely tied to the national small producer community. The initial membership of the group is given in Appendix A. The RAG will follow project's progress, plans and results and especially tech transfer. All projects will be reviewed by the RAG semi-annually.

While the RAG will be responsible for directing the Small Producer program, the Unconventional Onshore PAC will remain responsible for oversight of the entire onshore program, which includes the small producer program element. The RAG will interact with the Unconventional Onshore PAC through RPSEA Onshore VP and through its chairman who will hold a seat on the Unconventional Onshore PAC reserved for a representative of the Small Producer RAG. Strong communication between the RAG and the Unconventional Onshore Program will be required, as will effective communication between the RAG and the nationwide small producer communities.

Technical Advisory Committees (TAC)
While the Small Producer RAG will be the body primarily responsible for the management of the selection process for awards under the Small Producer program, the RAG will draw on the expertise of the specialized Unconventional Onshore TACs. These TACs will be available to provide in depth technical reviews on proposals that may fall outside the scope of the expertise present on the RAG. As directed by the RAG, TACs will also review the progress and outcome of the research, providing direction and insight.

G. Prioritized Technology Needs

The Small Producer program has been able to draw on the input from the exercises and workshops described in the Unconventional Onshore section of this plan, as well as specific events aimed at small producers conducted by RPSEA members New Mexico Tech and West Virginia University. The overarching theme expressed by small producer representatives at

these events is the need for technology which allows them to maximize the value of the assets that they currently hold. The hydrocarbon assets held by independent producers in the U.S. represent a known potential resource that can be exploited through application of appropriate technology that leverages existing knowledge and infrastructure without expansion of oil and gas development into frontier areas.

Following is a description of the planned Small Producer program, directed toward the specific requirements associated with the theme of **Advancing Technology for Mature Fields.**

H. Technology Challenges of Small Producers Research Program

With consideration given to the extensive planning and data gather activities and workshops conducted over the past three years, including input from advisory bodies and industry forums, RPSEA will implement the Small Producers R&D program with the following as goals, objectives, priorities, timing and expected outcome.

The Technology Challenges of Small Producers Research Program will include the following:

Goal:
Provide a positive benefit to the U.S. energy consumer through adding to the reserve base associated with mature fields operated by small producers a projected amount of new reserves equal in value to ten times the R&D investment in the small producer program element over the period 2007-2010. These reserve additions will result from increasing the recovery factor, applying technology to make economically marginal resources economic and decreasing the impact of development in environmentally sensitive areas.

Objective:
The program objective is to increase the contribution to U.S domestic energy production from small producers by addressing the technology challenges that will maximize production from the resource base associated with small producers while minimizing environmental impact.

Scope:
The program will be directed towards research, development, demonstration and commercial application of technologies. Application of results is crucial for program success including dissemination to the U.S. small producer. The U.S. onshore geologic basins are the primary area of focus. Coordination with the DOE Stripper Well Consortium will be essential in order to avoid duplication of effort.

Strategy and Approach:
Elements of the Small Producer R&D approach include:

- Producer Engagement Throughout
- Emphasis on Technology Impact and Utilization – Stage/Gate Process to Manage
- Field Based Research and Demonstration Component
- Technology Dissemination

- Determine Impact and Recalibrate Program as Required
- Efficiency and Flexibility Will be Required

Resource Focus:
The Small Producer program will focus on developing technology that will enhance the value of mature fields through reducing the cost, increasing the efficiency and decreasing the environmental impact of production, development and redevelopment of mature assets held by small producers.

The significant additional resource base associated with currently uneconomic reserves in fields that are currently in production or have been in production has the potential to contribute to the U.S. energy supply with minimal additional surface impact and infrastructure investment. The small producer community is willing and able to invest in the application of new technology to increase the production from their existing resource base, but does not have the resources to directly develop the required technology. This program is intended to develop and demonstrate the advanced technology solutions that will attract the required investment from small producers to maximize the contribution to national energy needs from existing mature fields. Technologies developed under the program will be mapped across all resources, irrespective of the initial area of resource application. Through this effort, technologies targeting a specific resource will find application in other regions of the country and for other resources, leveraging the R&D investment to the greatest extent possible.

The planned solicitation section reviews the topics and areas in the format of a request for proposals or solicitation.

I. Coordination with complementary NETL program

The 2007-2008 RPSEA Small Producer program is focused on developing technology to allow small producers to maximize the value of their existing mature asset base. The NETL complementary program will be focused on longer-term technology developments that might be applied in other unconventional resources, such as onshore deep gas. While there may not be direct application of technical results from the complementary NETL program to the RPSEA small producer program, close coordination with other NETL initiatives, such as the Stripper Well Consortium will be very valuable. The small producer program will be directed toward improving asset value at the field level, while the Stripper Well Consortium is aimed at improving well performance. The two programs are thus very complementary. RPSEA will coordinate with NETL staff responsible for the stripper well consortium and other relevant programs, as well as the RAG, to identify opportunities where work conducted under the RPSEA small producer program might benefit from explicit coordination with other NETL initiatives.

J. Technology Challenges for Small Producers Planned Solicitation

RPSEA plans to issue multiple solicitations throughout an Annual Plan calendar year. The initial solicitation is summarized below and the solicitation process is described in Appendix B. As the R&D program gets underway in a particular region or resource area, RPSEA anticipates that R&D issues not initially identified may develop resulting in the need for additional solicitations.

As the program is initiated, early solicitations will be broad in scope, allowing a broad range of research topics addressing key issues to be considered. The solicitation described below provides an example. As the program matures, subsequent solicitations will address more detailed and specific problems, building on earlier program successes It is also anticipated that the RPSEA management team might need to form research teams to effectively address individual problems. Past R&D has shown that the best entity to perform a specific scope of work does not always exist and must be developed.

Solicitation Summary – Advancing Technology for Mature Fields

Objective:
Identify and then demonstrate technologies, processes and tools that may be applied to substantially increase, in an environmentally sound manner, commercial production and ultimate recovery from the established reservoirs (or undiscovered/marginal reservoirs) associated with the currently or formerly producing assets of small producers.

Goal:
Increase the ultimate recovery from mature oil and gas fields, reduce environmental impact and reduce development costs associated with resource development.

Description:
In most onshore hydrocarbon reservoirs, up to 70% of the oil and 30% of the gas may remain in the formation when further production becomes uneconomic. These hydrocarbons represent a resource of known quantity in a known location that may be added to the economic resource base through the application of technology that improves the efficiency of development and production operations or reduces cost.

Hydrocarbons associated with mature fields are by definition located in areas that have been subject to hydrocarbon production operations. At the very least, roads are likely in place, and in the case of currently producing fields, the entire existing surface infrastructure may be leveraged for additional production.

In addition, these mature assets are typically held by small producers having a business model focused on extracting the maximum value from their asset base. While they do not have the financial capability to invest directly in focused technology development, they will readily invest in the application of new technology that has been proven to increase production and extend the life of their producing properties.

This solicitation is aimed toward development and proving the application of technologies that will increase the value of mature fields through reduced operating costs, decreased cost and environmental impact of additional development, and improved oil and gas recovery.

In order to ensure that technologies developed under this program are applied to increase production in a timely fashion, each proposal will be required to outline a path and timeline to an initial application. A specific target field for an initial test of the proposed development must be identified, and ideally the field operator will be a partner in the proposal.

In compliance with EPACT all awards resulting from this solicitation "shall be made to consortia consisting of small producers or organized primarily for the benefit of small producers". For the purposes of this solicitation, a consortium shall consist of two or more entities participating in a proposal through prime contractor-subcontractor or other formalized relationship that ensures joint participation in the execution of the scope of work associated with an award.

The participation in the consortium of the producer that operates the asset that is identified as the initial target for the proposed work is highly encouraged.

Scope:
Proposal solicitations in the Technology Challenges for Small Producers program area will request proposals for development of tools, techniques and methods that may be applied to substantially increase commercial production and ultimate recovery from established mature fields, including both currently producing and inactive fields. Reducing risk is a key – thereby reducing the cost and improving margins. Improved field management, best practices, lower cost tools (including software) are all within the scope. The concepts may include but will not be limited to the following areas:

- Development of approaches and methods for water management, including produced water shutoff or minimization, treatment and disposal of produced water, fluid recovery, chemical treatments and minimizing water use for drilling and stimulation operations.
- Development of methods for improving the oil and gas recovery factor.
- Development of techniques that will extend the economic life of a reservoir.
- Development of methods to reduce field operating costs, including reducing production related costs as well as costs associated with plugging and abandoning wells and well site remediation. Consideration will be given to those efforts directed at minimizing the environmental impact of future development activities.
- Development of cost-effective intelligent well monitoring and reservoir modeling methods that will provide operators with the information required for efficient field operations.
- Development of improved methods for well completions and recompletions, including methods of identifying bypassed pay behind pipe, deepening existing wells, and innovative methods for enhancing the volume of reservoir drained per well through fracturing, cost-effective multilaterals, in-fill drilling or other approaches.
- Well documented field tests of emerging technology that will provide operators with the information required to make sound investment decisions regarding the application of that technology in the targeted fields and elsewhere.
- Maximize the value of existing data through collecting and organizing well and field data from multiple sources in a readily accessible and usable format. Use data mining methods to extract information from old records and develop a database of information regarding mature properties that attracts additional development investment.

- Extending the commercial life of a producing well by identifying and ranking those candidates that would benefit the most from economic deployment related technologies.

Deliverables:
Anticipated deliverables from worked performed under this solicitation include but are not limited to the following:

- Reports including detailed process, procedures, software, manuals, and guidebooks and the like documenting the success or failure, and clearly explaining the cause-and-effect rationale for the observed results. Identification of analogous plays where the same procedures can be implemented.

- For projects involving innovative and commercially producible hardware, software, or processes; early identification of commercialization path will be imperative.

Technology Transfer:
Effective technology transfer will be essential and is considered a highly valued deliverable from the work. Early and continued producing and service company participation, and cooperative field work have been a key element of success in the past and must be pursued. Other technology transfer efforts would include preparation and presentation of technical papers, workshops, and seminars, both in person and recorded for virtual presentation. A key element of the technology transfer process associated with this program will be the initial application of the technology in the field identified in the proposal. RPSEA will maintain a publicly accessible web page that will house all reports and data resulting from the work. Research contractors shall be required to submit all their reports and data in electronic format for immediate access by the industry, co-researchers, all academic and technical institutions and individual researchers and consultants.

Section 5

PROGRAM IMPACTS

One of the overall objectives of the RPSEA program is to convert technically recoverable resources to economic production while protecting the environment, thus providing the U.S. gas consumer with a secure, affordable and reliable natural gas supply.

The methodology will determine program impact in several areas using a hierarchical approach. The following tables identify metrics at the program and project level as well as a set of parameters for more qualitative and/or process related metrics.

A. Program Level Impact; Parameters, Metrics and Goals

Parameter	Metric	Goal
Benefit to Consumers	TCF added and/or $/mcf reduction	Increase gas supply by x TCF of gas by 2010
Impact on Production	Increased Bcf of gas Production	y MMcf added production from active research program areas
Impact on Federal Royalty Receipts	$ added to Federal coffer as result of the program	Add $z million per year average

Table 5.1. Program level impact

The success of the RPSEA program will be evaluated by determining its impact on key factors such as the U.S. supply of natural gas, the rate of production of U.S. natural gas and the additional royalties paid to U.S. taxpayers as a result of increased production on federal leases. The placeholder goals in Table 5.1 above (x TCF, y MMcf, $z million) will be replaced by quantitative goals as the technology focus of the program evolves. The methodology described below will be used to translate the project level technological impact of RPSEA research to the high level goals that will measure impact on energy consumers in the U.S.

The overall program impact goals in Table 5.1 above will be quantified by calculating the impact new technologies achieve at the project level. Project level goals include topics such as increasing the supply of unconventional resources, reducing the costs to find, develop, and produce such resources, increasing the efficiency of exploration of such resources, increasing the efficiency of production, improving safety, and improving environmental performance. This will be done through use of existing model(s) that through a set of technology levers and/or parameters are able to quantify the impact of new technology. Table 5.2 below identifies those parameters and metrics.

1. Methodology and Methodology Discussion

Oil and gas production impacts can be quantified utilizing any of several existing models. Several organizations including the NPC, DOE and EIA conducted similar impact studies on a regular basis. RPSEA will adapt one or more of these processes to its particular needs as opposed to creating something from scratch.

Most of these models allow detailed inputs by region, type of gas/oil, drilling depth, and water depth and time period. The process requires assessment of generalized cost/performance using expert opinion, test results, reservoir simulation and other inputs. RPSEA will utilize its advisory structure and membership network to provide expert opinion for model assumptions and to review the results.

The approach anticipates a "base case" which would represent results without the RPSEA programs. "Impact cases" would then be run determining the impact of all or a subset of the RPSEA R&D program results. The outputs would include at the highest level the impact on:

- Benefits to the consumer
- Oil and gas production
- Royalty and tax payments

Databases used to support the model and forecasting can be used for other RPSEA planning information needs. Examples of such databases include annual or quarterly summaries of historical U.S. unconventional drilling, production, estimated reserve additions and estimated expenditures by area and play. Offshore Continental Shelf (OCS) drilling, production and development plans by areas of interest (e.g., specific deepwater areas, deep shelf) can also be included in the quarterly summaries.

The basic approach includes parameters for finding, developing and producing gas and oil using observable and verifiable engineering and cost parameters, standard discounted cash flow techniques, and forecasts based on explicit assumptions regarding the resource base, find rates, costs, technologies, finances and taxes, producer expectations and behavior.

Resource base assumptions are based on statistical analysis of extensive field, drilling and production databases. New fields are characterized by regional and depth interval. Remaining resource base is characterized in terms of number and size of remaining fields.

Old fields are characterized using separate economics for oil, high-perm gas, and low-perm gas fields and are characterized by old field exploratory drilling find rates, development drilling recoveries per well and well decline rates.

2. Steps and Timing for Establishing Quantifiable Goals

Many of the parameters and quantification of specific goals will require the research program to be implemented and underway before reliable goals can be established. It is proposed that the following steps be taken with regard to establishing program goals, final metrics and impact.

1. The R&D program needs to be initiated and first round proposals received before establishing project level goals.
2. During this time, RPSEA should review and select the most appropriate model for quantifying and tracking program impact.
3. After model selection, a baseline case should be established for all areas of RPSEA program research.
4. With the above information in hand, a projection of the program results based on an assumption of R&D budget per year for a specified number of years should be modeled.
5. From step #4 above, the exact and quantifiable program goals should be established. Most likely time frame would be late year 2007.
6. The process should be reviewed with each of the advisor groups before finalization.
7. The process will be repeated on yearly basis to quantify incremental program results and keep track of cumulative impact.

B. Project Level Impact; Parameters, Metrics and Goals

(Note: to establish goals for this level it will be necessary to implement the R&D program in specific areas. Those listed are examples only)

Parameter	Metric	Goal (examples only)
Impact on Resource Base	Increasing the supply of Unconventional resources	+ 1 TCF by 2010
Removes Constraints in Development Area	Added Acreage for Exploration	+ 200,000 acres
Environmental Impact	e.g., less drilling footprint, less water usage, reduced road building	1 acre reduced to .5 acres
Exploration Well Success	% of exploratory wells dry holes	+.5% Success Rate per Year
Development Well Success	% of development wells dry holes	
EUR per Well	Increased gas recovery per well	
Drilling Cost	Reduced $ per well	
Completion Cost	Reduced $ per well	
Initial Production Rate	Mmcf/day	
Infrastructure Cost	$ per well infrastructure	
OPEX	$ per well OPEX	

Table 5.2. Project level impacts

C. Process Level Impact; Parameters, Metrics and Goals

Parameter	Metric	Goal
Technology Dissemination	# of Technologies used by year and area	TBD
Industry Participation in the Program	Number of Workshop Participants, Reports Ordered, Field Test Partners	Active Participation in all Areas – Document greater than 1000 producers per year as participants
Science Building Value of Program	# Patents Issued, Copyrights, Peer Reviewed Technical Papers	Three Patents per Year by Program Year #3; Ten Technical papers per year by Program Year #3
Safety	Technologies Impacting Safety e.g., coiled tubing drilling systems	Difficult goal to Quantify
Environmental	Each Technology Developed in the Program Should Describe its Environmental Impact	All technologies at a minimum environmentally benign; a significant number with positive environmental features

Table 5.3 Process level impact

In addition to the goals noted in Table 5.3, and as detailed within the RPSEA Management Plan, a process will be implemented for tracking budgeted versus actual financial information and other project schedule parameters as follows:

Obligated/uncosted funding in relation to total project funds

RPSEA will establish a database to track obligated funding for the total program as well as for each project.

Earned value assessment for each research project including individual project cost and schedule variation - Earned value management (EVM) metrics will measure the cost and schedule performance of each research project. These metrics will be based on three essential variables:

- **Budgeted Cost of Work Scheduled (BCWS)** which is extracted from the initial project plan. This variable lays down the baseline of planned expenditures at any given time.
- **Budgeted Cost of Work Performed (BCWP)** is extracted from the initial plan and computed based on the reported work completed.
- **Actual Cost of Work Performed (ACWP)** is extracted from a project's periodic reports and is the actual expenditure to complete a given task.

From these three variables, RPSEA will determine the cost and schedule variance for each project.

Cost and schedule data will be collected from researchers on a schedule negotiated with the provider during the contract finalization process. The nature and characteristics of projects funded under the program will vary widely. The reporting frequency established for each project will consider these differences and vary as appropriate for individual projects, and will balance the need for information required to effectively monitor project execution against project schedules, milestones, and magnitude.

Project completion targets (within budget and project period)

RPSEA will utilize the three variables identified above to compute and report the estimated time at completion (ETAC) and estimated cost at complete (ECAC) for each project.

Adherence to project schedule (for solicitation and awards)

RPSEA will apply the same earned value techniques described above to the program level schedule for developing solicitations and making project awards. Earned value measurements will be made against the baseline schedule for the solicitation process.

In addition to the above, RPSEA will be developing procedures to capture, monitor, and analyze data based on the following and other relevant information to ensure the overall success of the RPSEA program
:

- Cost share
- In-kind contributions
- Small business, minority owned and other disadvantaged category program participants
- New product launches

Appendices

Appendix A

RPSEA Board of Directors and Advisory Committees

RPSEA Board of Directors

Board Member	Affiliation
Dr. Daniel H. Lopez – Board Chairman	New Mexico Institute of Mining and Technology
Dr. Eric J. Barron	University of Texas at Austin
Dr. Brian Clark	Schlumberger
Mr. Daniel D. Gleitman	Halliburton Energy Services
Mr. Michael G. Grecco	Chevron Energy Technology
Ms. Christine Hansen	Interstate Oil and Gas Compact Commission
Dr. Richard C. Haut	Houston Advanced Research Center
Dr. Stephen A. Holditch	Texas A&M University
Dr. Brooks A. Keel	Louisiana State University
Ms. Melanie A. Kenderdine	Gas Technology Institute
Mr. Dirk McDermott	Altira Group
Dr. Ernest J. Moniz	Massachusetts Institute of Technology
Mr. Mark B. Murphy	Strata Production Company
Ms. Maxine Natchees	Ute Indian Tribe
Mr. Rob Perry	BP America
Mr. Brook J. Phifer	NiCo Resources LLC
Dr. Colin Scanes	Mississippi State University
Mr. Matthew R. Simmons	Simmons & Company International
Mr. Timothy Tipton	Marathon Oil Company
Ms. Lori S. Traweek	The American Gas Association
Mr. Tony D. Vaughn	Devon Energy Corporation
Dr. John D. Weete	West Virginia University
Dr. Arthur B. Weglein	University of Houston
Mr. Thomas E. Williams	Noble Drilling Corporation
Mr. C. Michael Ming – RPSEA President	RPSEA

RPSEA Strategic Advisory Committee (SAC)

Strategic Advisory Committee Member	Affiliation
John Allen	GE/Vetco
Ralph Cavanagh	Natural Resources Defense Council
Peter Dea	Independent
Steven Holditch	Texas A&M University
Melanie Kenderdine	Gas Technology Institute
Vello Kuuskraa	Advance Resources International
Daniel Lopez	New Mexico Institute of Mining & Technology
Dirk McDermott	Altira Group
Michael Ming	RPSEA
Ernest Moniz	Massachusetts Institute of Technology
Mark Murphy	Strata Production
Donald Paul	Chevron
William Schneider	Newfield Exploration

RPSEA Ultra-Deepwater PAC

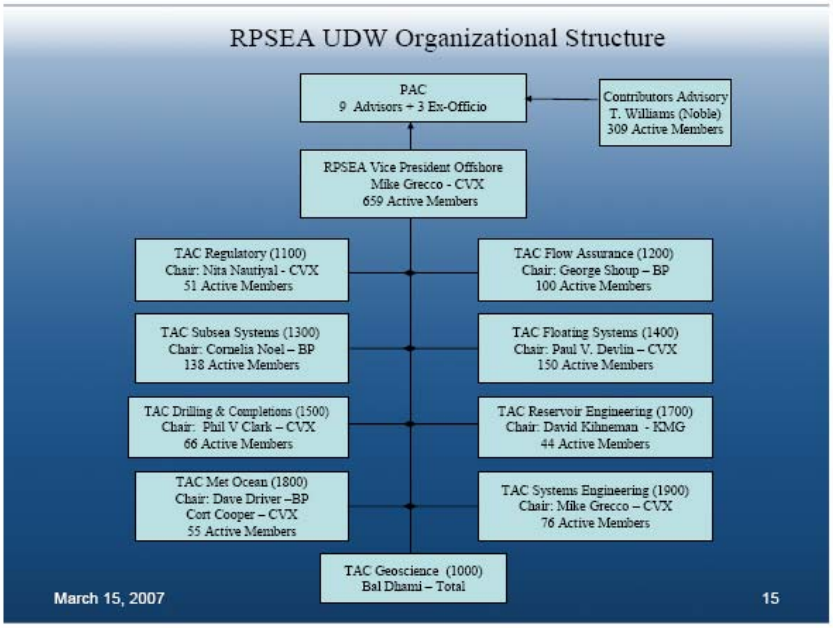
Name	Organization
Hugh Banon	BP
Gail Baxter	Marathon
Mike Grecco	Chevron
Ron Araujo	Anadarko
Bal Dhami	Total
Arnt Olufsen	Statoil
Luiz Souza	Petrobras
Maurizio Zecchin	ENI
Tom Williams	Noble Corporation (ex-officio)
Gary Covatch	NETL (ex-officio)
Roy Long	NETL (ex-officio)

RPSEA Unconventional Onshore PAC

Name	Company
Darrell Pierce	DCP Midstream, LLC
Steve McKetta	El Paso Corporation
Mark Malinowski	Rosewood Resources, Inc.
David Martinueau	Pitts Energy
Steve Sonnenberg	Anadarko Petroleum Corporation
Bill Van Wie	Devon Energy Corporation
John Lewis	Noble Energy
Mark Glover	BP America
Julio Friedman	Lawrence Livermore National Lab
Mark Murphy	Strata Production Company
Kurt Reinecke	Bill Barrett Corp.
Bob Boswell	Laramie Energy
Dr. John Lee	Texas A&M University
Bob Stayton	Weatherford International Ltd.
Dr. Valerie Jochen	Schlumberger Limited
Dr. Dag Nummedal	Colorado School of Mines (CERI)
Dr. Nafi Toksoz	Massachusetts Institute of Technology
Virginia Weyland	DOE (NETL) Ex-Officio

Small Producer Research Advisory Group

Name	Organization
Mark Murphy, Chair	Strata Production, Roswell, NM
Brook Phifer, Vice Chair	Nico Resources, Denver, CO
Bob Kiker	PTTC Permian Basin, Midland, TX
Chuck Boyer	Schlumberger, Pittsburgh, PA
Douglas Patchen	WVU, Morgantown, WV
Iraj Irshaghi	USC, Los Angeles, CA
Ben Hare	Panhandle Royalty, Oklahoma City, OK
TBD	Small Producer, Gulf coast, LA or AL
James Barnes	DOE (NETL), Ex-Officio



Environmental Advisory Group

Name	Organization
Dr. Rich Haut Chairman	Houston Advanced Research Council
	NGO's
	Universities
	Industry
	Service Companies

Appendix B

RPSEA Solicitation Process

Eligibility

In accordance with EPACT in order to receive an award, an entity must either be

a) a United States-owned entity organized under the laws of the United States; or
b) an entity organized under the laws of the United States that has a parent entity organized under the laws of a country that affords-
    a. to United States-owned entities opportunities comparable to those afforded to any other entity, to participate in any cooperative research venture similar to those authorized under this subtitle;
    b. to United States-owned entities local investment opportunities comparable to those afforded to any other entity; and
    c. adequate and effective protection for the intellectual property rights of United States-owned entities.

RPSEA is not eligible to apply for an award under this program.

Organizational/Personal Conflict of Interest

The approved RPSEA Organizational Conflict of Interest Plan will govern all potential conflicts associated with the solicitation and award process.

Advisory Committees and BOD Input

The overall structure of the solicitation and project selection process is illustrated in Figure B.1. The RPSEA BOD must approve the Plan before it is submitted to DOE. The TACs will be responsible for providing technical reviews of proposals, while the PACs will be primarily responsible for the selection of proposals for award.

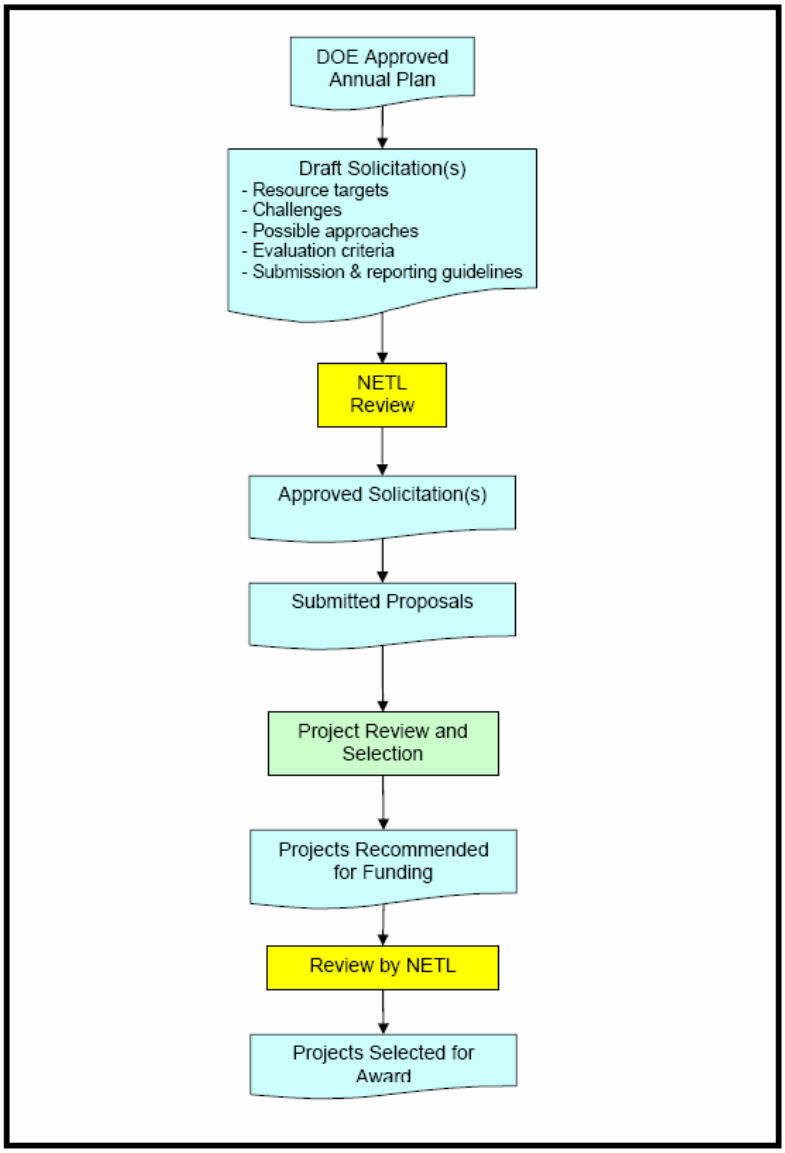


Figure B.1 RPSEA Solicitation Process

Information Applicable to All RPSEA Solicitations

Schedule
The schedule for the initial round of solicitations will be determined in consultation with NETL after an approved Annual Plan is available.

Funding Estimates

It is anticipated that $14.9 million will be available for the UDW program element and $13.8 million for the Unconventional Resources program element during fiscal year 2007. Approximately 15 to 20 awards are anticipated within each program element. The typical award is expected to have duration of one to two years, although shorter or longer awards may be considered if warranted by the nature of the proposed project.

It is anticipated that $3.18 million will be available for the Small Producer program element during fiscal year 2007. Approximately 8 to 12 awards are anticipated. The typical award is expected to have duration of two years, although shorter or longer awards may be considered if warranted by the nature of the proposed project.

Selection Criteria:
The following criteria will be used to evaluate proposals submitted under the RPSEA program. Weighting factors will be determined prior to the issuance of each solicitation.

- Technical merit and applicable production or reserve impact
- Statement of Project Objectives
- Personnel qualifications, project management capabilities, facilities and equipment, and readiness
- Technology transfer approach
- Cost for the proposed work
- Cost share
- Environmental, Health and Safety QA/QC
- Exceptions to contract terms and conditions

The following additional criterion will be used to evaluate proposals submitted under the Small Producer program element.

- Approach to application of the results, including involvement by small producers

Oversight:
All work performed under the RPSEA program will be conducted under the supervision and management of the RPSEA management associated with the relevant program element.

Appendix C

Unconventional Resource Opportunities

A brief description of tight sands, gas shales, and coalbed methane resources follows, highlighting the size of the resource and some of the unique challenges associated with each. The following Figure C.1 identifies the geologic basins in the lower 48 United States which contain unconventional gas resources. Practically every basin in the U.S. has some concentration of these resources which requires any research program to prioritize and focus its efforts to assure results. Table C.1 quantifies the volume of technically recoverable gas by basin. The total technically recoverable resource base approaches 300 TCF in size which clearly underscores the justification for a R&D program with conversion of technically recoverable resource to economic gas production.

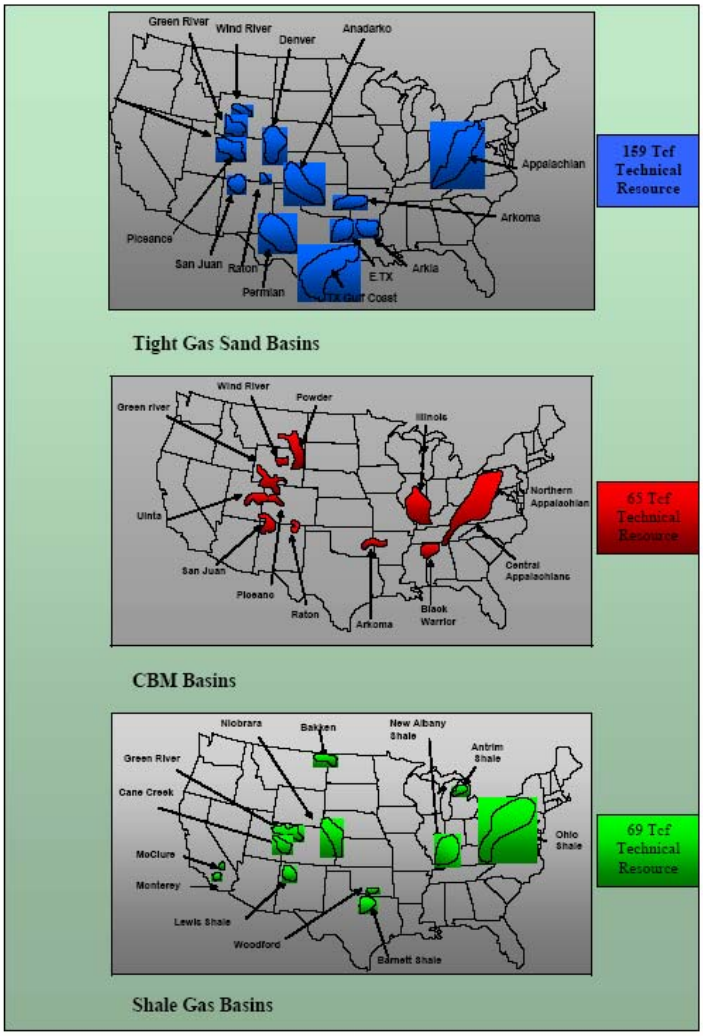


Figure C.1 Unconventional Gas Geologic Basins in the Lower 48 United States

Basins/Regions	Gas Shales	Coalbed Methane	Tight Gas	Total
Appalachian Basin	16,986	8,158	34,746	**59,890**
Black Warrior Basin	0	4,465	0	**4,465**
Mississippi, South Alabama, and Florida	0	0	0	**0**
Michigan and Illinois Basins	7,300	1,580	0	**8,880**
East Texas, South Arkansas, & North Louisiana	0	0	10,400	**10,400**
South Louisiana (Onshore)	0	0	0	**0**
South Texas (Onshore)	0	0	4,600	**4,600**
Williston, Northern Great Plains	0	0	7,660	**7,660**
Utah-Piceance Basin	0	5,862	27,500	**33,362**
Powder River Basin	0	26,600	764	**27,364**
Big Horn Basin	0	0	0	**0**
Wind River Basin	0	413	0	**413**
Southwestern Wyoming (Green River Basin)	0	1,966	38,800	**40,766**
Denver Basin, Park Basins, Las Animas Arch	0	0	2,019	**2,019**
Raton Basin-Sierra Grande Uplift	0	1,931	0	**1,931**
San Juan and Albuquerque-Santa Fe Rift	0	8,413	21,002	**29,415**
Montana Thrust Belt and Southwest Montana	0	0	0	**0**
Wyoming Thrust Built	0	0	0	**0**
Great Basin and Paradox	0	0	0	**0**
Western Oregon-Washington	0	676	11,846	**12,522**
Anadarko Basin	1,000	0	0	**1,000**
Arkoma-Ardmore	9,300	2,558	0	**11,858**
Northern Mid-continent	0	2,295	0	**2,295**
Permian	34,400	0	0	**34,400**
Northern California	0	0	0	**0**
Central and Southern California	321	0	0	**321**
Total	**69,307**	**64,917**	**159,337**	**293,561**

Table C.1 Unconventional Gas Technically Recoverable Resource Base – TCF

Tight Gas Sands

Tight gas sands are characterized by their very low permeability and require fracture stimulation to achieve economic production rates. Flow from tight sand reservoirs is normally through open natural factures feeding into the hydraulically created fractures. Tight sand gas is the most abundant of all unconventional resources of the U.S. and occurs in many of the US sedimentary

basins. The estimated technically recoverable resource from established tight sand reservoirs is estimated at 159 TCF (Table C.1).

Coalbed Methane

Accumulation of methane in coal seams differs from that in other sedimentary rocks in that the gas molecules are adsorbed to coal particles, as well as occupying the pore space/natural fracture systems as a gaseous phase. This adsorption of methane to coal is pressure dependent. As the pressure is reduced, the gas is desorbed and can flow through the coal cleat system. The common practice in coalbed methane (CBM) production involves dewatering of the seams to reduce the ambient pressure. It is not unusual to pump water for up to one year before any methane is produced.

Production from the coalbed methane resource (Figure C.2) experienced a dramatic increase during the last decade. Annual production increased from 0.2 TCF in 1990 to over 1.9 TCF by 2005. The estimate of technically recoverable gas from CBM resources is in excess of 64 TCF (Table C.1).

Gas Shales

Historically, gas shales have been the least active and lowest volume producer of the unconventional gas resources. This is rapidly changing with the gas shale resource exceeding coalbed methane as the most sought after resource. While it is currently the lowest volume producer it is anticipated to grow in production by the largest percentage. Major gas shales occur in the Appalachian, Central and Rocky Mountain regions, Michigan, East Texas, Oklahoma, and Arkansas. The volume of technically recoverable gas from all lower 48 gas shale basins estimated by the NPC exceeds 69 TCF (Table C.1.) Production from gas shales has been historically at low rates and therefore, the development has been limited to shallow depths where low production rates would still be economic. However, recent advances in drilling technology, namely extended reach horizontal drilling, and development of efficient fracture stimulation applied in the Barnett Shale play have resulted in significant production increases thereby turning the Barnett Shale into the most active gas play of recent years. It is therefore expected that enhancement of the technology and its modification and transfer to other basins will provide grounds for sizeable upward revision of this resource.

Other Unconventional Natural Gas Resources

Complex carbonate reservoirs, deeper gas deposits, and basin-centered gas constitute a distinctly different class of unconventional resources typified by being obscure to geophysical imaging, difficult to drill, and having unpredictable production rate. In spite of all recent advances in petroleum exploration and production technologies, exploration for and development of this class of unconventional resources has remained extremely risky and difficult. For example, high pressure and temperature in deeper reservoirs are far beyond the limits of drilling, completion, and survey tools and as such, development of these resources at commercial scale awaits the development of new tools and materials capable of handling these extremely harsh conditions.

Because of these difficulties and requirements; and in view of time and funding limitations of the RPSEA program, no major research and development efforts specifically targeting these resources are planned in the initial program. Nonetheless, as some of these resources are underlain by tight sand and gas shale resources, the understanding of geologic structures, depositional environment; tectonics and diagenetic histories resulted from this program would

contribute to better understanding of deeper resources thereby facilitating their future development.

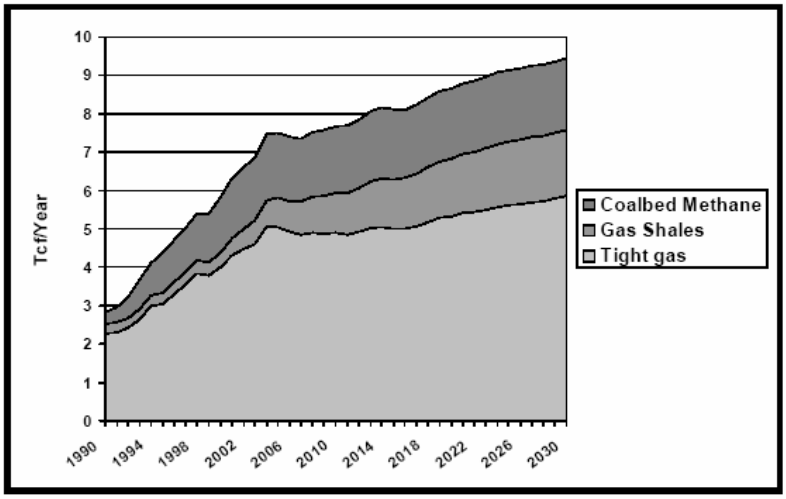


Figure C.2 Current and Projected natural gas production from unconventional resources of the Lower-48 States. (EIA, 2005, "Annual Energy Outlook 2005", Energy Information Administration, U.S. Department of Energy, Washington, D.C., DOE/EIA-0383(2005)

Appendix D

Unconventional Resources Technical Input

Summary of Technical Input Used in Developing the Plan

The sections below describe some of the details of the input gathered via the activities listed in Table 3.3 of this plan. Most of the specific research areas that were given high priority in the reports summarized below will contribute to the design and priorities developed within this annual plan, and will guide the solicitations planned.

RPSEA/New Mexico Tech Unconventional Gas Technology Workshops

Over 70 people participated in the five workshops conducted across the country. A web based survey was also performed to identify and prioritize unconventional gas technology needs. The following Table D.1 summarizes the topics of greatest priority by region of the country.

Topic	San Juan	Permian	Oklahoma	West VA	Rocky Mt.
Reservoir characterization, imaging	•	•	❶	❶	❶
Stimulation	•	❶	❶		
Play-based resource assessment		•		❶	•
Data mining, data collection			❶	❶	
Producibility models			❶		
Handling, treating and disposal of produced water	❶				
Extending well life				❶	
Advanced drilling technologies, drilling cost reduction	•			•	
Completion strategies for horizontal wells		•			
Expert systems		•			
Processing of low-BTU gas		•			
Removal of liquids from deep gas wells		•			
Core drilling/evaluation				•	
Production performance monitoring and evaluation					•

1 = Top Priority

Table D.1 New Mexico Tech Unconventional Gas Workshop Priorities (Engler, Thomas W., Ron Broadhead, Martha Cather and William D. Raatz, 2003, "Technology Roadmap for Unconventional Gas Resources", GRI-03/0060, Gas Technology Institute, Des Plaines, IL.)

National Petroleum Council 2003 Natural Gas Study

The National Petroleum Council conducted a comprehensive natural gas study during 2002 and 2003. Included was a detailed assessment of unconventional gas resources and technology needs. The NPC reached the following conclusions. For the unconventional gas resource, just four super-regions (Rockies, Eastern Interior, Alaska, and Western Canada Sedimentary Basin) contribute 90% of the undiscovered potential. Conventional gas production in the U.S. lower 48 has been declining since 1990 and unconventional production has doubled from 12% to 25% of production. Aside from the deepwater GOM, the only U.S. basins maintaining sustainable production increases (Rockies, East Texas/North Louisiana) are being driven by increased unconventional production. This is a technology sensitive resource that will require ongoing technology advancements to become an economic resource. Through a series of producer workshops technology issues and needs were identified and presented in Table D.2.

Technology Area	Technology Needs
Multi-Zone Well Completion	• Technology for construction of fishbone well patterns. • Directional control within thin coal formations.
Smaller Well Footprint	• Ability to drill and produce CBM wells on small surface locations. • Technology allowing greater well spacing.
Rapid Technology Transfer	• Information technology including use of the internet to rapidly share and disseminate best practices.
Produced Water Technology	• Technology and understanding of issues related to changing produced water from a waste to a valued resource.
Improved Gas Recovery per Well	• More effective well stimulation techniques. • Completion designs to enhance drainage.
Technology Integration – Development Planning	• A systematic approach to developing a CBM field integrating all technology needs development, including the ability to evaluate coal seams prior to completing wells. • Effective methods to simulate coal bed performance

Technology Area	Technology Needs
Rig designs to reduce "flat-time", and provide safer, environmentally-friendly operations	• Small modular rigs with sate-of-the-art pump equipment, automated pipe handling, and control systems. • Casing drilling, coiled tubing drilling • Environmentally-friendly drilling fluids, • Multi-lateral with long-reach horizontal configurations to reduce number of surface locations
Tight sands Low recovery wells from small pools, thin sands, low porosity	• Improved fracture stimulation • Technologies focused on reducing cost per mcf • Bottom-hole compression increase production of low pressure reservoirs • Multi-lateral, steerable, extended reach wells to maximize reservoir wellbore exposure to the reservoir
Reservoir monitoring	• Further enhancement of 4D technology to find undepleted areas of the reservoir • Permanent sensors for real-time measuring and reservoir monitoring

Table D.2; National Petroleum Council (NPC) 2003 Technology Issues and Needs

With respect to the unconventional gas area, the NPC identified several key findings as a result of the study:

- Technology improvements play an important role in increasing natural gas supply.
- The gas exploration and production industry should collaborate more effectively with the DOE in the planning and execution of complementary, not competitive, research and development programs.
- Investments in research, development and application of new technology have declined over the last 10 years.
- Adding new North American natural gas supplies will require finding, developing and producing more technologically challenging resources than ever before.
- Environmental and safety concerns are significant drivers in the development and application of new technologies.
- As more unconventional gas resources are developed, the average permeability of the producing reservoirs will continue to decrease, requiring the industry to find and apply new technologies and best practices that enable low permeable wells to produce at

economic flow rates. The industry will be challenged to find methods to locate "sweet spots" in tight basin-centered gas fields, gas shales and coal bed methane reservoirs, thus reducing the number of marginally commercial wells being completed.

DOE Sponsored Unconventional Gas Workshops

The technology needs identified through the roadmapping workshops conducted during 2005 readily aligned themselves into three high-priority research topics as specified below (Table D.3).

Group I **Development and Characterization of New Resources**	• Resource Assessment • Basin-Scale Petroleum Systems Studies • Field-Based Testing
Group II **Reduced Development Costs of Existing Resources**	• Data Access • Reservoir Characterization • Production Prediction and Optimization • Advanced Well Construction
Group III **Crosscutting Topics**	• Basic Research • Environmental and Land Access • Manpower

Table D.3; High Priority Research Areas from Year 2005 Unconventional Gas Workshops

The topics in Group I represent activities that are necessary if substantial new unconventional gas resources are to be identified and developed sufficiently to meet the anticipated demand for unconventional gas. While the impact of these activities is not immediate, they are essential if the anticipated contribution of unconventional gas to the U.S. resource base is to be realized.

Group II includes topics that will assist operators in increasing production in the near term. These topics are aimed toward problems that producers are currently experiencing and for which solutions will find a ready market.

Finally, the issues in Group III address all aspects of unconventional gas development. While Basic Research received considerable support both directly and as an element of other topics, Manpower and Environmental and Land Access seemed to take a back seat in priority to more specific technical areas of concern. Nevertheless, there was a considerable amount of discussion in the workshops regarding these last two topics, and their alignment with the Findings published in the 2003 NPC study reinforces their importance.

A matrix of the prioritized technology issues from the workshops by region is presented in the following Table D.4.

Research Topic/Issue	Total Votes
Houston Workshop	
Basic Research	25
Field-Based Testing (MWX/SFE Type)	21
Resource Characterization	17
Infrastructure Development	9
Personnel Training/Development	7
Golden Workshop	
Data Collection and Availability	18
Predictability of Production	15
Advanced Well Construction Technology	15
Basin Scale Petroleum Systems Studies	15
Environmental – Produced Water & Land Access	14
Pittsburgh Workshop	
Reservoir/Resource/Play Characterization	12
Resource Assessment	12
Database Compilation	12
Production Prediction and Optimization	10
Stimulation Technology	7

Table D.4; High Priority Research Issues from Year 2005 Unconventional Gas Workshops

RPSEA Forums

RPSEA conducted eleven forums during late 2006 and early 2007. The forums continue to be conducted on an ongoing basis as need is identified. Sharing ideas, progress and growing the RPSEA network are critical elements for the success of the RPSEA Partnership. For this reason, RPSEA continues to host conferences on key strategic topics and we encourage attendance at industry conferences whose topics cover areas related to the broad scope of issues aligned with RPSEA's Vision of increasing the domestic energy supply.

To date eleven forums have been conducted on topics important to unconventional gas and deep water resources. Topics have included:

- Appalachian Regional Theme Forum,
- Seismic E&P Forum,
- Autonomous Intervention for Deepwater O&G Operations Forum,
- Tight Gas, Gas Shales Gas & Coalbed Methane Forum
- Problem Identification Forum
- Gas Shales Forum
- Produced Water Forum

- Small Producer Forum
- Vortex Induced Vibrations Forum
- Flow Assurance Forum
- Seafloor Technologies Forum

Attendance in the eleven forums is over 750 participants. The following Table D.5 identifies research and technology development needs identified at the forums that have particular relevance to the unconventional gas program.

RPSEA Forum Series Research Needs and Technology Issues
Reservoir Characterization
Permeability/producibility in tight formations: controls, distribution and prediction
Gas storage in shales: mechanisms and controls
Fracture characterization in shales and tight sands
Coalbed methane permeability
Seismic imaging of complex structures
Drilling and Completion
Best practices/optimized production methods; environmental, drilling, completion, stimulation
Stimulation: design and modeling
Formation damage prevention and mitigation
Low impact/high performance drilling
Improved Oil Recovery
Cost effective additional recovery factor
Affordable technology for heavy oil
Leverage with CO_2 sequestration
Environmental
Surface disturbance including well sites and roads
Air quality related to oil and gas operations
Groundwater quality
CO_2 Sequestration
Impact of oil and gas operations on wildlife
Cuttings Disposal and Waste Management
Water Management
CBM – surface discharge; soil chemistry issues, treatment limits
CBM – treatment and beneficial use
Water shutoff: improved chemical treatments
Improved re-injection methods
Cost effective application of reverse osmosis or alternative desalinization methods
Inhibiting water production from fractures without impeding oil or gas production
Identify new sources of water for oil and gas operations
Cost effective and reliable downhole separation methods

RPSEA Forum Series Research Needs and Technology Issues
Resource Evaluation Classify what reservoirs work and why Improved methods to learn from drilling results and identify sweet spots Natural fracture importance and detection Field experiments – similar to M-site Pressure measurement in low-perm rocks; core analysis, define the plumbing system How to model shales the way we model sands – materials + fluids + chemistry
Tight Gas Issues Identify potential future resource plays Reservoir hetereogeneity; understand reservoir vs. matrix permeability, controls on "sweet spots" Petrophysics – improved pay identification Rock properties – effect of stress Drainage areas – radial or elliptical Effect of hydraulic fractures vs. refracs; understanding and modeling
CBM Issues Advanced drilling and completion technologies Produced water management CO_2 Storage and enhanced recovery Production from thin, unmineable coal seams Production of coal mine methane Pumping large volumes of water/fines Improved completions, stability issues
Gas Shales Issues Understanding reservoir pressure Reservoir modeling; geomechanical, fracture interference, post-frac water production Analytic models for desorption, gas/condensate behavior Geomechanical/geochemical models of hydraulic fracturing, including multilaterals Definitions and models of fluid flow, leakoff mechanisms Standardized definitions of physical properties (porosity, permeability, etc.) Stress dependence of physical properties Geologic/geochemical controls on shale properties Evaluation kerogen type, thermal maturity, gas composition Occurrence and diffusion of free gas Mechanism for capturing and disseminating data and information

Table D.5; Summary of RPSEA Forum Results

RPSEA Onshore Unconventional Gas PAC

As discussed earlier, the Onshore PAC met for their inaugural meeting February 6, 2007 in Houston, Texas. The primary objective for this meeting was to establish an initial framework for the unconventional gas research program.

The PAC prioritized the U.S. unconventional gas resource both by area of geologic activity (geologic formation and by technology hurdles or barriers that currently stand in the way of further economic development. Near term versus long term considerations and balance for the program was discussed. The degree to which one of the three major unconventional resources (tight gas sands, gas shales, coalbed methane) should be emphasized by the research program was also determined.

The following matrix (Table D.6) illustrates the outcome of the prioritization exercise for the geologic formation portion of the exercise.

	CBM	Gas Shales	Tight Sands
Existing Play			
45%	San Juan 11	Barnett 12	Green River 11
	Appalachian 8	Appalachian 11	S. Texas 9
			Uinta-Piceance 8
	0	6	7
Emerging Gas Play			
45%	Uinta-Piceance 9	Permian 9	Uinta-Piceance/Deep 8
		Woodford-Oklahoma 5	
		Trenton-Black River 3	
	0	12	1
Frontier Area			
10%	Illinois Basin 4	Permian-Woodford 12	Western Oregon/Washington 7
	N. Mid-Continent 3	Green River 5	
	0	12	2

Table D.6; Unconventional Gas Resource Prioritization Matrix

Within Table D.6, the yellow highlight represents the highest ranked formations for each of the respective unconventional resources with the number representing votes received.

The number highlighted in green represents the resource and type of play i.e., existing play, emerging gas play or frontier area; determined to be of highest priority. Plays were defined as:

- Frontier Area - Formations, depth intervals, or geographic areas from which there has been no prior commercial development.
- Emerging Gas Play - Formations, depth intervals, or geographic areas from which there has been limited commercial development activity and very large areas remain undeveloped.

- Existing Play - Active Development Drilling and Production

The percentage numbers on the left side of the matrix represents the percentage of the program that should be allocated to each of the timeframes, existing through frontier.

A second exercise was to identify the issues or barriers that prevented economic development of the unconventional gas resource. The results of this exercise are included in the following Table D.7.

Unconventional Gas Development Barriers
Environmental
Minimize operations footprint
Water Management
Produced water
Wellbore-Reservoir Access/Connectivity
Horizontal drilling
Hydraulic fracture
Other stimulation methods
Advanced completion methods
Resource Potential/Characterization (Shales)
Core and Log Analysis
Geophysical and Geochemical Data
Pre-Drill Prediction
Reservoir Characterization
Sweet Spot Controls and Predictions
Imaging
Modeling
Cost Reduction

Table D.7; Technology Priorities Developed with the Unconventional Onshore PAC

National Petroleum Council Global Oil and Gas Study

The National Petroleum Council initiated a study in late 2006 to evaluate the Oil and Gas situation around the World in an attempt to evaluate the location and size of these resources. Several committees were formed one of which addressed unconventional gas and another technology. RPSEA participated in both. The unconventional gas team evaluated technology deemed important for development of that resource using three time frames; now to 2010, 2010 to 2020 and the year 2030. The technology under development or needed was identified. Its importance or priority relative to other technology was determined and a brief discussion of each

developed. The following Tables D.8 to D.10 summarize the most important unconventional gas technologies from now to the year 2030.

Unconventional Gas Technology Under Development or Anticipated by 2010	Need	Discussion
Fracture modeling and analysis, full 3-D models for new types of treatments	High	Incorporating new physics for fracture propagation, in naturally fractured reservoirs, proppant transport, and better models for horizontal and multilateral wells
New fracturing fluids and proppants	High	Strong, light weight proppants are needed. Better fluids that do not damage the reservoir and fracture must be developed
Hydraulic fracturing methods used in horizontal wells	High	Fort Worth basin (Barnett Shale) Increased production rate by 2 - 3 times rate of vertical well
Stimulation methods used in naturally fractured formations	High	Gas shales and coal seam reservoirs are normally naturally fractured. We need a better understanding and better technologies for such reservoirs to include better models to determine gas storage and gas production using multiple gas systems, such as CO_2, wet gas and N_2
Micro-seismic fracture mapping and post fracture diagnostics	High	Fort Worth basin (Barnett Shale) Improved understanding of hydraulic fracturing in horizontal wells so that designs can be improved
Data collection and availability during drilling, completions, stimulations and production	High	Significant data are being generated by increased drilling and new tools and techniques. The ability to handle and use data is being challenged. The data need to be evaluated in detail to learn more about formation evaluation, fracture treatments and production
Integrated Reservoir Characterization of geologic, seismic, petrophysical and engineering data	High	More complex reservoirs, lower permeability, greater depth and more cost require a more in-depth understanding of reservoir petrophysics. Better models will be required to properly integrate all the data and optimize the drilling and completion methods.
Horizontal Drilling and Multi-lateral Wellbore Capability	High	Enables development of stacked, thin bed coal seams and reduces environmental impact. Also need to develop multiple wells from a single pad. This technology is very important in gas shales reservoirs, and sometimes important in tight gas reservoirs.
Reservoir Characterization through laboratory measurements	High	We need better core analyses measurements for basic parameters such as permeability, porosity and water saturation. In coal seams and shales, we need better methods for estimating sorbed gas volumes and gas in place values in the reservoir.

Unconventional Gas Technology Under Development or Anticipated by 2010	Need	Discussion
Reservoir Imaging Tools	High	Understanding the reservoir characteristics is an ongoing challenge and priority for all unconventional reservoirs.
Overall Environmental Technology	High	We need to reduce the impact of operations on the environment by reducing waste, reducing noise, smaller drilling pads and adequate handling of waste water.
Produced Water Handling, Processing and Disposal	High	Coal seams and gas shales continue to produce significant volumes of water. Efficient handling and environmentally safe and low impact disposal are needed.
Personnel Training/Development	Moderate	Changing and developing technologies, increased activity and environmental challenges require a highly technical and efficient workforce.
Basin Scale Petroleum Systems Studies and Resource Assessment	Moderate	Understanding of each geologic basins complete tectonic and depositional history is needed to establish fundamentals for future exploration and additional recovery of hydrocarbons for both thermogenic and biogenic hydrocarbons.
Basic Research	Moderate	Ongoing development of fundamentals in all technical disciplines will be necessary as challenges continue to increase.
Rapid Technology Transfer	Moderate	Information technology including use of the internet to rapidly share and disseminate best practices.

Table D.8; Summary of currently developing technologies for unconventional gas from now to 2010

2020 Technology for Unconventional Gas Reservoirs	Need	Discussion
Real-Time Sweet Spot Detection While Drilling	High	Will allow the steering of the drill bit to most productive areas of the reservoir.
Coiled Tubing Drilling for Wells Less Than 5000 ft.	High	Will allow the advantages of continuous tubing drilling to be realized (fast drilling, small footprint, rapid rig moves) to be realized for currently difficult drilling areas.
3D seismic applications for imaging layers and natural fractures in shale reservoirs	High	We could improve recovery efficiency from existing wells if we used well testing methods to better understand the reservoirs

2020 Technology for Unconventional Gas Reservoirs	Need	Discussion
Produced Water Processing	High	Produced Water is processed and utilized such that it no longer is viewed as a waste stream but as a valuable product for agriculture, industrial use and for all well drilling and completion needs.
Deep Drilling	High	We need to determine how deep we can develop coalbed methane, gas shales and other naturally fractured unconventional reservoirs.
ECBM via CO_2 injection/sequestration	High	We need to determine the technological solutions and screening of suitable deposits/CO_2 pairs
Data Handling and Data Bases	High	Data bases are available and user friendly allowing access to geologic and engineering data for most North American basins, and are being developed for geologic basins worldwide.
Re-completion and re-fracturing technologies	Medium	Small diameter tools, re-fracturing technology, behind pipe hydrocarbon detection, lateral drilling technology have all developed and been integrated for increasing recovery from all know unconventional gas fields.
Technology Integration – Development Planning	Moderate	A systematic approach to developing a CBM field integrating all technology needs development, including the ability to evaluate coal seams prior to completing wells. Effective methods to simulate coal bed performance are required.
Fractured shale formation testing techniques	Moderate	We could improve recovery efficiency from existing wells if we used well testing methods to better understand the reservoirs
Reservoir simulation methods to incorporate all the layered reservoir description, the horizontal wells and the effect of hydraulic fractures	Moderate	We need to better understand the reservoir to plan infill drilling and completion methods needed to optimize gas recovery
Shale facies identification using geochemical source rock analysis and well logs	Moderate	A better understanding of the fundamentals will lead to an increase in the exploration success rate in gas shales reservoirs.

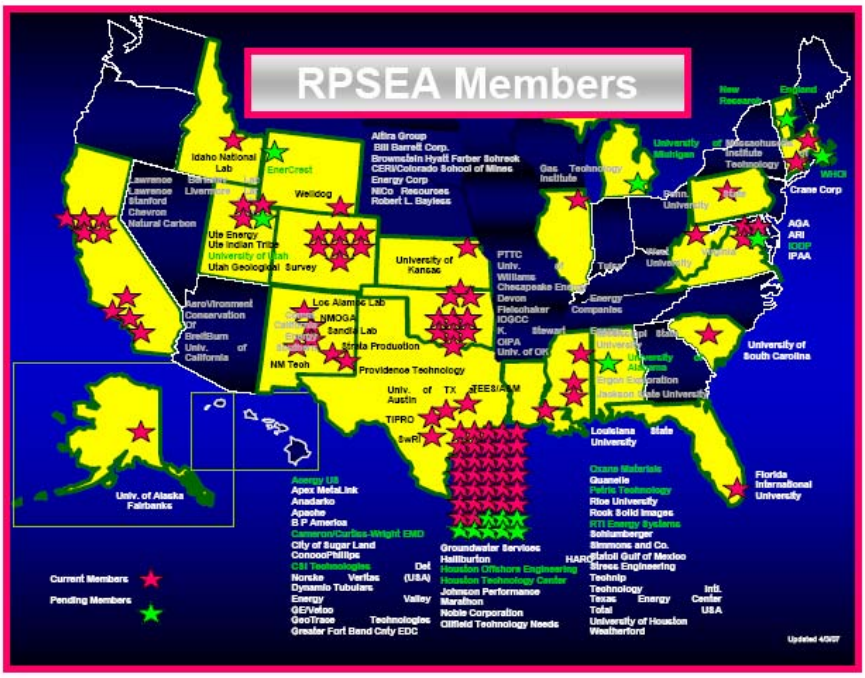
Table D.9; Summary of technologies for unconventional gas for Year 2020

2030 Technology for Unconventional Gas Reservoirs	Need	Discussion
Resource Characterization and Gas in Place Potential	High	All of the basins worldwide need to be assessed for unconventional gas potential. The results should be recorded in databases and made available to the producing community around the world.
Well Drilling and Completion	High	Well drilling technology must be advanced through improvement in down hole drilling systems, better metallurgy and real-time down hole sensors allowing drilling to sweet spots, use of under-balanced drilling where needed, advantages of continuous tubing drilling and efficient utilization of multilaterals.
Enhanced Recovery	Moderate	Well life must be extended through technology integration increasing gas recovery significantly over what is achievable in 2006
Worldwide Technology Dissemination	Moderate	Unconventional gas technology must be disseminated throughout the world. Production will be developed in most of the basins around the world and data will be readily available on the technologies used and the geologic information of each play is also available.
Coalbed farming	Moderate	Biogenic gas stimulation and recovery in situ

Table D.10; Summary of technologies anticipated for 2030

Appendix E

RPSEA Membership



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Acronyms

BCF	Billion cubic feet
BO	Barrels of oil
BOD	Board of Directors
BOE	Barrels of oil equivalent (1 BOE = 5.7 MCF gas)
BOEPD	Barrels of oil equivalent per day
BOPD	Barrels of oil per day
CBM	Coalbed methane
DOE	Department of Energy
DOI	Department of the Interior
E&P	Exploration and production
EAG	Environmental Advisory Group
EIA	Energy Information Administration
EPACT	Energy Policy Act of 2005
GOM	Gulf of Mexico
GTI	Gas technology Institute
IPAA	Independent Petroleum Association of America
MCF	Thousand cubic feet
MMCF	Million cubic feet
MMS	Minerals Management Service
NETL	National Energy Technology Laboratory
NGO	Non-Government Organization
NMT	New Mexico Institute of Mining and Technology
NPC	National Petroleum Council
PAC	Program Advisory Committee
PPM	Parts per million
R&D	Research and Development
RAG	Research Advisory Group (Small Producer)
RFP	Request for Proposal
RPSEA	Research Partnership to Secure Energy for America
SAC	Strategic Advisory Committee
SAIC	Science Applications International Incorporated
SME	Subject Matter Expert
TAC	Technical Advisory Committee
TCF	Trillion cubic feet
UDW	Ultra-deepwater

Appendix D: Federal Advisory Committee Comments on Draft Plan

This material will be added after it is received and any revisions to the draft plan based on these comments have been made.